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Three Essays on Wealth and Income Inequality

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Three Essays on Wealth and Income Inequality

Aaron Cooke

Three Essays on Income and Wealth Inequality

Aaron Cooke, PhD

University of Connecticut, 2018

In this dissertation I answer questions surrounding the division of wealth and income in the U.S. economy. In the first 2 essays I look at the impact of fertility and transfer taxes on the wealth distribution. In the final essay I use recession to show motivators behind occupational sorting.

Three Essays on Income and Wealth Inequality

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M.A., University of Connecticut, 2017

B.A., Westmont College, 2011

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Doctor of Philosophy Dissertation

Three Essays on Income and Wealth Inequality

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1. Essay 1

The literature shows that standard heterogeneous agents models struggle to replicate the magnitude of the wealth inequality observed in the data. For example, the Gini coefficient of the wealth distribution generated in a baseline [Aiyagari \(1994\)](#) model is only around 0.4, while the U.S. wealth gini coefficient is close to 0.8 (see [Quadrini and Ríos-Rull \(1997\)](#)). An important part of the puzzle is that the rich save more and spend less than predicted by standard models, and consequently accumulate a large amount of wealth. According to [Alvaredo et al. \(2013\)](#), the top 1% of households in the U.S. hold nearly one third of the total wealth and the top 5% holds over half, an order of magnitude larger than their counterparts generated in standard models.

Why is the wealth distribution so unequal? Why do rich people hold such a high amount of wealth? An important existing explanation offered in the literature is from [De Nardi \(2004\)](#), who emphasizes the role of bequests and intergenerational links. [De Nardi \(2004\)](#) finds that the rich are much more likely to leave bequests to their children compared to their poorer counterparts, even after accounting for the relative wealth between the two groups. Based on this finding, she created a model incorporating bequests into the utility function as a luxury good, and finds that this model is capable of accounting for the high concentration of wealth in the data, and that bequeathing behaviors are important in shaping the distribution of wealth. However, the [De Nardi \(2004\)](#) model assumes an identical fertility rate among the population, and thus abstracts from the fact that the poor tend to have more children than the rich, a dimension of heterogeneity we argue is relevant for understanding the wealth distribution. In this paper, we contribute to the literature by extending the [De Nardi \(2004\)](#) model to incorporate differential fertility choice among the

population, and analyze the implication of differential fertility for the wealth distribution through its interaction with the bequest mechanism.

Economists have long argued that there exists an inverse relationship between income and fertility.¹ For instance, Jones and Tertilt (2008) document a strong negative relationship between income and fertility choice for all cohorts of women born between 1826 and 1960 in the U.S. census data. They estimate an overall income elasticity of fertility of about -0.38. We argue that this significant fertility difference between the poor and the rich can amplify the impact of bequests on wealth inequality, because not only do rich parents leave a greater amount of bequests than their poorer counterparts, but the children of rich parents have fewer siblings to share their bequests with relative to the children of poor parents.

To capture the interaction between differential fertility and bequests, and to assess its quantitative importance for understanding the wealth distribution, we develop a general equilibrium overlapping generations (OLG) model with the “warm-glow” bequest motive (similar to that used in [De Nardi \(2004\)](#)) and differential fertility. Using a version of our model calibrated to the U.S. economy, we find that the fertility difference between the rich and the poor increases the Gini coefficient of wealth by about 5%, driven especially by about a one quarter increase in the wealth share of the top 1 %. This compares with models in [De Nardi \(2004\)](#) where she showed that intergenerational inheritance of ability increases the Gini coefficient by 3% and bequest motive increases it by 10%. We also quantify the importance of the bequest mechanism by showing that an alternative model in which the bequest channel has been shut down results in a much lower Gini coefficient of the wealth distribution, i.e., 0.68, compared to our benchmark value of 0.79. In addition, we find in our model that anticipated bequests crowd out life-cycle savings, which

¹See [De La Croix and Doepke \(2003\)](#), [De la Croix and Doepke \(2004\)](#), among others.

implies that intergenerational transfers can lead to less capital formation. In sum, this paper finds that pairing bequest motive with differential fertility is quantitatively important for explaining the saving behaviors of the rich and the consequent high level of wealth inequality.

1.1. Literature Review

Ever since heterogeneous agent macroeconomic models have been introduced to the macroeconomics literature by [Bewley \(1986\)](#) and [Aiyagari \(1994\)](#), a surge in papers have used this class of models to explain the causes and mechanisms behind wealth inequality. As surveyed by [De Nardi \(2015\)](#), there have been many variations of the heterogeneous agent model in which introduce various mechanisms to better match the magnitude of wealth inequality observed in the data, such as preference heterogeneity ([Krusell and Smith \(1998\)](#), [Heer \(2001\)](#), [Suen \(2014\)](#)), entrepreneurship ([Cagetti and De Nardi \(2006\)](#)), high earnings risk for the top earners ([Castaneda et al. \(2003\)](#)), transmission of bequests across generations ([Knowles \(1999\)](#), [De Nardi \(2004\)](#), and [De Nardi and Yang \(2016\)](#)), and others. Among these, our paper relates to the literature espousing bequest transmission across generations as a main mechanism behind wealth inequality.

The two papers in this literature closest to ours in spirit are [De Nardi \(2004\)](#) and [Knowles \(1999\)](#). [De Nardi \(2004\)](#) uses a quantitative, general equilibrium, overlapping-generations model in which bequests and ability link parents and children. The element in which our papers differ is in our treatment of fertility. In [De Nardi \(2004\)](#), each agent has the same number of children. In our model agents have a different number of children depending on the income, impacting the results in interesting ways. Our model is also close in spirit

to Knowles (1999), who uses a two period model to show the importance of fertility to inequality. In his model, there is no retirement period, which means savings that occur in his model are solely for the purpose of bequests. In contrast, the agents in our model must save for their own retirement on top of bequests. Therefore, our model captures the dynamic interaction between life-cycle savings and anticipated bequests. We show this interaction is quantitatively important for understanding the wealth distribution. In addition, our model differs from Knowles (1999) in terms of the choice of the bequest motive. While bequests are assumed to be motivated by altruism in the Knowles (1999) model, we adopt the “warm-glow” bequest motive based on the empirical literature we will discuss below.

It is well-known in the literature that intergenerational transfers account for a large fraction of wealth accumulation.² However, the literature has been at odds as to how to model bequest motives, specifically whether bequests are motivated by altruism. Altonji et al. (1992) found that the division of consumption and income within a family are codependent, indication that perfect altruism does not apply to operative transfers. Other studies show that an increase in parental resources coupled with a decrease in child consumption does not lead to a corresponding increase in transfers (Altonji et al. (1997) and Cox (1987)). Altonji et al. (1997) find a one dollar transfer from child to parent results in only a 13 cent donation from parent to child, which should be the full dollar under perfect altruism. Wilhelm (1996) finds siblings generally receive equally divided inheritances, rather than the size of the inheritance being dependent on relative income as perfect altruism would predict.³ Based on these empirical findings, multiple recent papers have assumed

²For instance, see Kotlikoff and Summers (1981), Gale and Scholz (1994), among others.

³Note that the nature of intergenerational links can be different in developing countries that feature different institutions and less generous public insurance. For instance, we find in the Chinese data that intergenerational transfers are highly dependent on the financial and health states of parents, suggesting strong altruism between parents and children.

an alternative bequest motive: the *warm-glow* motive.⁴ That is, parents derive utility from giving while not caring directly about the wellbeing of the recipient. In addition, motivated by the highly skewed distribution of bequests, these papers incorporate leaving bequests into the utility function as a luxury good, allowing for rich parents to value bequests relatively more. Following the tradition in these papers, we also adopt the “warm-glow” motive and assume bequests are a luxury good.

Our paper also relates to a growing number of papers that have shown that allowing for transfer of ability and human capital across generations is also an important element for understanding inequality. These studies include [Kotlikoff and Summers \(1981\)](#), [Knowles \(1999\)](#), [De Nardi \(2004\)](#), [De Nardi and Yang \(2016\)](#), and among others. Of special note, [Lee et al. \(2015\)](#) find that parental education is positively related to their children’s earnings, thereby creating a virtuous cycle for the wealthiest and a vicious cycle for the poorest.

The rest of paper is organized as follows. In Section 2, we describe the model and its stationary equilibrium. In Section 3, we calibrate a benchmark model. In Section 4, we discuss the main quantitative results and provide further discussion in Section 5. We conclude in Section 6.

2. The Model

Consider an economy inhabited by overlapping generations of agents who live for three periods. In the first period, agents are not economically active, only incurring costs to their parents. In the second period, they make consumption and labor supply decisions, and save for retirement. In the final period, they receive bequests from their dying parents,

⁴See [De Nardi \(2004\)](#), [De Nardi and Yang \(2016\)](#), among others.

consume some of their wealth and leave the remainder as bequests to their own children.

2.1. Consumer's Problem

2.1.1. Period One

An individual makes no economic decisions in the first period, but imposes a time cost on her parents. She inherits an ability level from her parents. An individual's ability ψ (effective units of labor representing human capital, luck or inherent ability) depends on their parental ability ψ^p , and the log of ability is assumed to follow the AR(1) process,

$$\log(\psi) = \rho \log(\psi^p) + \epsilon_{\psi}$$

where

$$\epsilon_{\psi} \sim N(0, \sigma_{\psi}^2), \quad \text{i.i.d.}$$

in which ρ is the intergenerational persistence of productivity. We discretize the AR(1) into 11-state Markov chain using the method introduced in [Tauchen \(1986\)](#), and the corresponding transition matrix we obtain is denoted by $M[\psi, \psi']$.

2.1.2. Period Two

Individuals in the second period differ along three dimensions: earning ability ψ , number of siblings n^p (or the parent's fertility), and current wealth of their elderly parents x^p . In this period, they jointly choose current consumption and save for period three. In addition, they raise n number of children, which is assumed to be an exogenous function of

their earning ability ψ , that is, $n = n(\psi)$.⁵ Therefore, the value function of an individual in period two can be specified as follows:

$$V_2(\psi, n^p, x^p) = \max_{c,a} \left[\frac{c^{1-\sigma}}{1-\sigma} + \beta V_3(x) \right]$$

subject to

$$\begin{aligned} c + a &\leq \psi w(1 - \gamma n(\psi)) \\ x &= a + \frac{b^p(x^p)}{n^p}. \end{aligned}$$

Here, the current utility flow is derived from consumption c according the CRRA form, and β stands for the time discount factor. Agents are given a time allocation set to unity. In the budget constraint, γ is the time cost per child per parent, and thus $(1 - \gamma n(\psi))$ simply represents the amount of time available to be allocated to the labor force. This implies that $\psi(1 - \gamma n(\psi))$ is the total amount of effective labor supplied, with w measuring the real wage per effective unit of labor. Note that because child costs are delineated in time, higher earning parents will effectively be paying more for their children, as is expected and reflected in the data. We also restrict a , the amount saved, to be strictly non-negative, thereby imposing imperfect capital market. In other words, agents cannot borrow to finance their retirement.

The second constraint of the maximization problem describes how total amount of wealth in the third period x is determined. It is the sum of life-cycle savings a , and the share of bequests received from dying parents b^p/n^p . Here, b^p denotes the bequest left by

⁵We also analyze an extended model with endogenous fertility later to explore the sensitivity of our main results to the assumption of exogenous fertility.

the parent, which is a function of the parent's total wealth x^p at the beginning of the third period. It is obtained from solving the utility maximization problem for the third period. It is important to note that the bequest is shared by all children of the parent, and thus what each child receives is negatively affected by the number of siblings she has. From the utility maximization problem in Period 2, we obtain two policy functions: optimal consumption $C_2(\psi, n^p, x^p)$ and optimal asset accumulation $A(\psi, n^p, x^p)$.

2.1.3. Period Three

Individuals retire in the third period and jointly choose current consumption and the amount of bequests for her children. Their state in this period can be captured by a single variable, x , the amount of wealth held, which is simply the sum of life-cycle savings and the share of bequests received from their dying parents at the beginning of Period 3. Individuals in Period 3 face the following utility-maximization problem:

$$V_3(x) = \max_{c,b} \left[\frac{c^{1-\sigma}}{1-\sigma} + \phi_1 (b + \phi_2)^{1-\sigma} \right]$$

subject to

$$c + b \leq (1 + r)x,$$

where b is the total amount of bequests left for children in the next period. Here we follow De Nardi (2004) and assume that parents have “warm glow” motive, where they enjoy giving to their children but do not directly care about the children's wellbeing, and in addition bequest is assumed to be a luxury good. As we reviewed in the introduction, this assumption is consistent with sizable empirical evidence. The term ϕ_1 measures the rela-

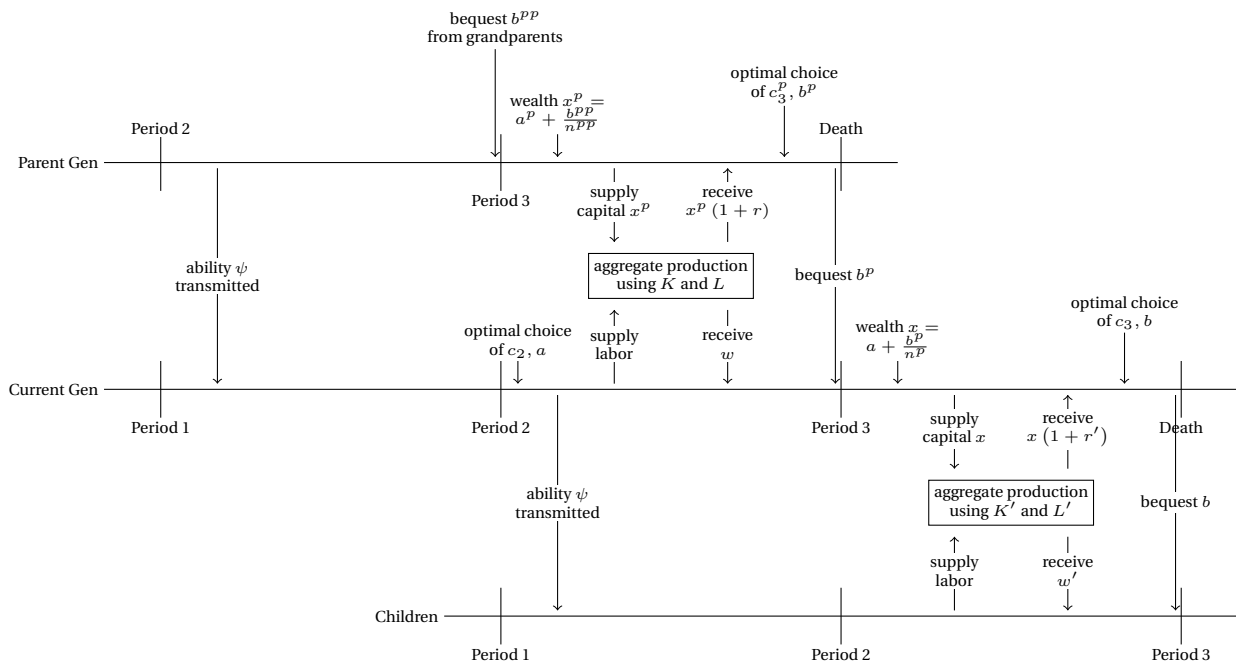


Figure 1: Sequence of Events for Current Generation

tive weight placed on the bequest motive, while ϕ_2 measures the extent to which bequests are a luxury good. From this maximization problem, we obtain two policy functions: optimal consumption $C_3(x)$ and optimal bequests $B(x)$.

Figure 2 contains the timeline summing up the sequence of events that happen throughout the lifecycle.

2.2. Firm's Problem

Firms are identical and act competitively. Their production technology is Cobb-Douglas, which combines aggregate capital K and aggregate labor L to produce output Y as follows

$$Y = zK^\theta L^{1-\theta}$$

in which θ is the capital share and z is the total factor productivity (TFP).

The profit-maximizing behaviors of firms imply that

$$r = z\theta K^{\theta-1}L^{1-\theta} - \delta$$

and

$$w = z(1 - \theta)K^\theta L^{-\theta},$$

where δ represents the capital depreciation rate.

2.3. Stationary Equilibrium

Let Φ_2 and Φ_3 represent the population distributions of individuals in period 2 and 3. A steady state in this economy consists of a sequence of allocations $[c_2, c_3, a, b]$, aggregate inputs $[K, L]$ and prices $[w, r]$ such that

1. Given prices, the allocations $[c_2, c_3, a, b]$ solve each individual's utility maximization problem
2. Given prices, aggregate capital and labor $[K, L]$ solve the firm's problem.
3. Markets clear:

$$K' = \int_{\psi} \int_{n^p} \int_{x^p} \left[A(\psi, n^p, x^p) + \frac{B^p(x^p)}{n^p} \right] d\Phi_2(\psi, n^p, x^p)$$

$$L' = \hat{n} \int_{\psi} \int_{n^p} \int_{x^p} (1 - \gamma N'(\psi, n^p, x^p)) \psi d\Phi_2(\psi, n^p, x^p)$$

where \widehat{n} is the average number of children the current period two individuals have.

4. The distributions Φ_2 and Φ_3 are stationary in the steady state and evolve according to the following laws of motions:

$$\begin{aligned}\Phi_2(\psi', n^{p'}, x^{p'}) &= \frac{1}{\widehat{n}} \int_{\psi} \int_{n^p} \int_{x^p} I_{x^{p'}=A(\psi, n^p, x^p) + \frac{b^p(x^p)}{n^p}} I_{n^{p'}=n(\psi)} M[\psi, \psi'] n(\psi) d\Phi_2(\psi, n^p, x^p) \\ \Phi_3(x^{p'}) &= \frac{1}{\widehat{n}} \int_{\psi} \int_{n^p} \int_{x^p} I_{x=A(\psi, n^p, x^p) + \frac{b^p(x^p)}{n^p}} d\Phi_2(\psi, n^p, x^p)\end{aligned}$$

where $M[\cdot]$ is the Markov transition matrix, I 's are the indicator functions. The ability distribution in the next period depends on the current period young's fertility. In the third period, an individual's wealth is what he has saved in the previous period, as well as what he has received in bequests from his parents. Note that the distribution of the elderly's wealth holdings is identical to the distribution of the young's parental wealth holdings (i.e., $x = x^{p'}$).

The rest of the paper focuses on stationary equilibrium analysis. Since analytical results are not obtainable, numerical methods are used to solve the model.

3. Calibration

We calibrate the model to match the current U.S. economy, and the calibration strategy we adopt here is the following. The values of some standard parameters are predetermined based on previous studies, and the values of the rest of the parameters are then simultaneously chosen to match some key empirical moments in the U.S. economy.

Table 1: The Benchmark Calibration

Parameter	Value	Source
z	1.0	Normalization
σ	1.5	Macro Literature
θ	0.36	Macro Literature
δ	0.04	Macro Literature
γ	0.2	Haveman and Wolfe (1995)
ρ	0.4	Solon (1992)

Parameter	Value	Moment to match
β	0.90	annual interest rate: 0.04
ϕ_1	-0.33	bequest/wealth ratio: 0.31
ϕ_2	0.086	pop. share with bequests < third of mean income
σ_ψ^2	1.15	Income Gini: 0.63

3.1. Demographics and Preferences

One period in our model is equivalent to 30 years. Individuals enter the economy when they are 30 years old (Period 2). They retire at 60 years old (Period 3) and die at the end of the third period (at 90 years old).

The parameter in CRRA utility, σ , is set to 1.5 based on the existing macro literature. The subjective discount factor β is calibrated to match an annual interest rate of 0.04, which gives us an annual discount factor of 0.90. We calibrate our bequest parameters to ensure that the level and distribution of bequests generated from our benchmark model matches their respective data counterparts. Specifically, ϕ_1 is calibrated to match the aggregate bequest to wealth ratio: 0.31 according to the estimation by [Gale and Scholz \(1994\)](#). A positive value of ϕ_2 implies that bequests are luxury goods, and its value controls the skewness of

the bequests distribution. According to the empirical estimation by [Hurd and Smith \(2002\)](#), about 90 % of the population do not receive a significant amount of bequests (i.e. less than half of average lifetime income). [Gale and Scholz \(1994\)](#) report that 96% do not receive inheritances above 3 thousand. In the benchmark calibration, we calibrate the value of ϕ_2 so that 90% of agents in the benchmark model receive bequests that are less than a third of median individual lifetime income.

We use the 1990 U.S. census data to calibrate the fertility choices for each group in our benchmark model⁶. We follow the approach in [?](#) and use the Children Ever Born to a woman as the fertility measure. Specifically, we use the sample of currently married women ages 40-50 (birth cohort 1940-50), and then organize the respondents into 11 ability groups corresponding to our model distribution by Occupational Income, corrected for a 2% growth rate.⁷ We believe the propensity of death on childbirth during this time period is low enough that the child mortality risk is not a significant issue. We take the mean fertility rate for each group and assign it to the corresponding group of agents in our benchmark model to generate the appropriate level of differential fertility by income.⁸ The resulting fertility-income relationship from our calibration exercise is reported in [Table 15](#), which is consistent with the estimation results in [?](#). For instance, the income elasticity of fertility is estimated to be -0.20 to -0.21 for the cohorts of women born between 1940 and 1950 in [?](#), while the implied income elasticity of fertility from our calibrated fertility distribution is -0.22.

⁶Courtesy of Steven Ruggles, Katie Genadek, Ronald Goeken, Josiah Grover, and Matthew Sobek. Integrated Public Use Micro data Series: Version 6.0 [dataset]. Minneapolis: University of Minnesota, 2015. <http://doi.org/10.18128/D010.V6.0>.

⁷Here we follow [?](#) closely and use the husband's occupational income to avoid the selection bias in women's employment status.

⁸Note that the fertility choice in our model is the per parent fertility so we follow the tradition in the fertility literature and halve these fertility rates calculated from the data when using them in the model.

3.2. Technology and Earning Ability

The capital share θ is set to 0.36, and the capital depreciation rate is set to 0.04. Both are commonly used values in the macro literature. The value of TFP parameter, z , is normalized to one.

We approximate the AR(1) process for earning ability ψ by an 11-state Markov chain using the method introduced in [Tauchen \(1986\)](#). The coefficient of intergenerational persistence, ρ , is set to 0.4 according to the estimates in [Solon \(1992\)](#). We calibrate the income variance σ_ψ^2 so that the income Gini coefficient generated from the model matches the value of 0.63 that [Castaneda et al. \(2003\)](#) estimated using the 1992 Survey of Consumer Finances data. We report the resulting ability levels in [Table 15](#) and the corresponding transition matrix can be seen in [Section ??](#) of the Appendix. In addition, we set the time cost of children γ to be 0.2 of parental time per child based on the empirical estimates of [Haveman and Wolfe \(1995\)](#).

The key parameter values and their sources are summarized in [Table 13](#).

4. Quantitative Results

We start this section by reviewing the main properties of the benchmark model at the steady state, with special attention given to its implications for wealth inequality. We then run counter-factual computational experiments to highlight the impact of differential fertility and bequests on wealth inequality.

Table 2: Benchmark Model Statistics

Name	Model	Data
Annual Interest Rate	0.04	0.04
US Aggregate Bequest/Wealth Ratio	0.31	0.31
Average fertility rate per household	2.3	2.3
Gini Coefficient of the US Income Distribution	0.64	0.63
Income Elasticity of Fertility	-0.22	-0.20/-0.21

4.1. Some Key Properties of the Benchmark Economy

A key element of our theory is the negative income-fertility relationship, which is best measured by the income elasticity of fertility. As we mentioned previously, the income elasticity of fertility implied by our benchmark model is very close to its empirical counterpart estimated by [?](#) . Another important part of our theory is the skewed distribution of bequests with a long right tail. We ensure the model matches the bequest distribution we observe in the data by modelling bequests as luxury goods in the fashion of [De Nardi \(2004\)](#) and [De Nardi and Yang \(2016\)](#). In addition, our calibration strategy implies that our benchmark model matches the bequest-capital ratio and the 90th percentile of bequest amount.

Table [14](#) contains some key statistics of the benchmark economy together with their data counterparts. As can be seen, our calibrated benchmark model matches the key empirical moments from the US economy fairly well. Table [15](#) summarizes the ability distribution generated by our benchmark model, along with how the average fertility calculated by ability groups match up against the data. The first row represents the relative value of the ability ψ_i for Group i , in which the value for Group 6 is normalized to unity. The second row is the share of the population whose ability is equal to or less than that group. Hence,

Table 3: Fertility-Income Relationship from the Benchmark Model

Ability Group i	1	2	3	4	5	6	7	8	9	10	11
ψ_i	0.02	0.04	0.09	0.21	0.46	1.0	2.19	4.81	10.56	23.16	50.80
Cumulative Mass	0.004	0.015	0.064	0.185	0.383	0.617	0.815	0.937	0.985	0.996	1.0
Fertility per Parent	1.6	1.6	1.4	1.4	1.25	1.15	1.08	1.07	0.96	0.86	0.88

Group 11—the highest ability group in our model—corresponds to the top 0.4% and the top two groups together correspond to the top 2% of the population.

4.2. Wealth Inequality in the Benchmark Economy

In this section, we examine the wealth distribution generated in our benchmark model. We compute the proportion of overall wealth held by each percentile group in our benchmark model and compare it against the data. Some key statistics of the wealth distribution are reported in Table 16.⁹ The richest 1% from our benchmark model hold less wealth than the data, but overall our model does a moderately accurate job of matching the actual distribution of wealth in the U.S., especially among the top 20%. As can be seen in the last column, our benchmark model also matches the Gini coefficient of the wealth distribution closely. It is important to note that these statistics of the wealth distribution are not used as our targeted moments in the calibration.

The data comes from the Survey of Consumer Finances, which has an oversample of wealthy families and a weighting scheme that corrects for under-coverage at the top of the wealth distribution. This attempts to correct for the outsize role that non-respondents among the very wealthy would play in creating a non-representative sample.

To understand the role of differential fertility and bequests in shaping the U.S. wealth

⁹A graphical distribution of wealth generated from our benchmark model can be seen in Figure ??.

Table 4: Wealth Distribution: Model vs Data

Percentile	< 60%	60–80 %	> 80%	90–95 %	95–99 %	>99%	Gini Coef.
Data	0.08	0.13	0.79	0.13	0.24	0.30	0.78
Benchmark Model	0.05	0.13	0.82	0.18	0.30	0.19	0.79
Identical Fertility	0.07	0.16	0.77	0.17	0.26	0.15	0.75
Identical Fertility+No Bequest	0.11	0.18	0.71	0.15	0.23	0.14	0.68

Data source: [Diaz-Gimenez et al. \(1997\)](#)

inequality, in the rest of this section we conduct two counter-factual computational experiments in which each of the two factors is assumed away respectively. In the first counter-factual experiment, we impose identical fertility to show the effects of differential fertility on the distribution of wealth and bequests. In the second counter-factual experiment, we eliminate the bequest motive to highlight the impact of bequests on wealth inequality. From these two counter-factual experiments, two things become clear. We find that bequests significantly increase the level of wealth inequality, and fertility differences between the rich and the poor amplify this effect, especially for the far right of the wealth distribution. In addition, we find that life-cycle saving and anticipated bequests interact with each other, with expected bequests crowding out life-cycle saving for retirement. This interaction is quantitatively important for fully understanding wealth inequality in the United States.

4.3. Counter-factual Experiment I: Identical Fertility

To highlight the important role of fertility differences across the income groups in amplifying the impact of bequests on wealth inequality, we consider a counter-factual experiment in which fertility is assumed to be identical across the income distribution. That is,

we force everyone in the model to have the same fertility choice, 1.15 per parent, and recalibrate the model using exactly the same strategy and the same empirical moments as in the benchmark model.

The main results from this counter-factual experiment are also reported in Table 16. We find that allowing for differential fertility can have important ramifications for the wealth distribution, as evidenced by the Gini coefficient of wealth distribution, and the share of wealth held by the top 1% respectively increasing by around 4% and by about a quarter.

The reason why the counter-factual model with identical fertility performs worse than the benchmark model with differential fertility can be best understood when we analyze the distribution of bequests generated from the two models. Table 5 highlights the differences. In the benchmark model, we obtain an extremely skewed distribution of bequests in which the top 1% are responsible for 43% of total bequests at the steady state. In fact, the top 10% are responsible for almost all the bequests. As a result, the Gini coefficient is very high at 0.96. In contrast, the counter-factual model with identical fertility obtains a lower value of Gini coefficient of 0.90. This decrease mainly results from the fact that the share of total bequests from the top 1% and the top 5% drop significantly. We argue that this change in the distribution of bequests is an important reason why the counter-factual model generates a lower wealth inequality. The intuition behind this result is the following. When children are receiving their bequests, poor children have more siblings and rich children have fewer siblings relative to the identical fertility case. This leads to less division of estates than would otherwise be the case for the richest groups, causing increased concentration of wealth at the highest income levels and greater diffusion at the lower income levels.¹⁰

¹⁰The reason the rich have fewer children than the poor is a question that remains without a definitive an-

Table 5: Bequest Distribution: Benchmark vs. Identical Fertility

Percentile	< 90%	90–95 %	95–99 %	>99%	Gini Coef.
Benchmark	<0.01	0.09	0.48	0.43	0.96
Identical Fertility	0.12	0.23	0.39	0.26	0.90

It is also interesting to examine the life-cycle saving behaviors in the two versions of the model. We find that life-cycle saving and anticipated bequests interact with each other, which is important for understanding the wealth distribution. That is, anticipated bequests have a crowding out effect on life-cycle saving. As shown in Table 6, the Gini coefficient for the distribution of life-cycle saving from the benchmark model is 0.72 and the top 20% account for 0.74 of the savings, which is lower than that from the counter-factual model with identical fertility. On the surface, this result is puzzling because you would expect the rich from the counter-factual model to be saving less than the rich from the benchmark model. That is, the rich in this counter-factual economy are forced to have more children than otherwise they would have, therefore they spend more time raising children and receive less labor income than in the benchmark model. Assuming the same saving rates in the two models, the life-cycle saving distribution should be less unequal in the model with identical fertility.

The reason why the distribution of life-cycle saving becomes more unequal after shutting down differential fertility is because of the interaction between anticipated bequests and life-cycle saving. In other words, the more unequal life-cycle saving distribution seen in the identical fertility model is simply the endogenous response to the less unequal distribution of bequests in this counter-factual model. Given that the wealth distribution is

swer in the literature. Please see ? for a complete literature review on this topic.

Table 6: Distribution of Life-Cycle Saving

Percentile	< 60%	60–80 %	> 80%	90–95 %	95–99 %	>99%	Gini Coef.
Benchmark Model	0.10	0.16	0.74	0.14	0.25	0.18	0.72
Identical Fertility	0.09	0.15	0.76	0.15	0.26	0.17	0.73

jointly determined by the distributions of life-cycle saving and bequests, the crowding out effect from anticipated bequests on life-cycle saving weakens the impact of bequests on wealth inequality. In the next section, we provide further discussion of this effect together with some empirical evidence on the relationship between life-cycle saving and anticipated bequests.

4.4. Counter-factual Experiment II: Alternative Bequests

To highlight the role of bequests on wealth inequality, we now consider several counter-factual experiments in which we alter the bequest motive. In other words, we create a new counterfactual economy by changing the bequest motive in the first counterfactual economy. This allows us to parse out the effects of fertility and bequests. We will be running three counter factuals. Each will analyze the affect that our bequest function has on our untargeted wealth distribution, in order to see the importance of our functional form in our results.

The first will no longer have the bequest motive represented by a luxury good-instead it will be treated as a normal good. Computationally, we set ϕ_2 equal to null, and recalibrate ϕ_1 to match only the bequest capital ratio, and ignore the targeted 90th percentile of the bequest distribution. We would expect this to reduce bequest inequality, and therefore make the distribution of wealth more equal.

The second and third eliminate the bequest motive altogether, one with differential fertility, and one with identical fertility. Computationally, we set ϕ_1 equal to null, which means no bequests ever take place at the steady state, and recalibrate the rest of the parameters in the same way as in the benchmark model. The reason we are running this model twice is to isolate the effect of fertility on labor market contributions, which gives us an idea how important that channel is in our benchmark model for generating the high degree of wealth inequality.

Results from these experiments are shown in Table 7.

The elimination of the luxury good element from the benchmark model does in fact reduce inequality, especially among the top 1%. As the middle class increases their bequesting, wealth in the economy becomes less concentrated. We conclude that the luxury good assumption is critical for the high degree of inequality we generate in the benchmark model. The model with bequests that are not luxury good generates a wealth distribution almost identical to a model without bequests.

Comparing the model with Identical Fertility and No Bequest to the model with Differential Fertility and No Bequest, we can see the impact of fertility on the time spent in the labor force. Furthermore, comparing the model with Differential Fertility and No Bequest to the Benchmark model allows us to find the impact on wealth distribution from the division of estates between children. Using this deconstruction, we conclude that the estate division is more important in our model for generating a high degree of wealth inequality. Specifically, including the estate division channel increases wealth holdings of the top 1% by about a quarter, and increases the Gini coefficient by about a tenth. This compares to our time cost channel generating an increase in the Gini coefficient of about 6%.

Table 7: Wealth Distribution: Benchmark vs No Bequests

Percentile	< 60%	60–80 %	> 80%	90–95 %	95–99 %	>99%	Gini Coef.
Benchmark Model	0.05	0.13	0.82	0.18	0.30	0.19	0.79
Differential Fertility + No Luxury	0.09	0.17	0.74	0.15	0.24	0.15	0.72
Differential Fertility + No Bequest	0.09	0.17	0.75	0.16	0.24	0.15	0.72
Identical Fertility + No Bequest	0.11	0.18	0.71	0.15	0.23	0.14	0.68

Data source: [Diaz-Gimenez et al. \(1997\)](#)

5. Further Discussion

5.1. An Extended Model with Endogenous Fertility

We assume that fertility choices are exogenous in our benchmark model. This assumption significantly simplifies our analysis, and helps us avoid the complicated theoretical issues that arose in the literature on the negative income-fertility relationship (see ? for a complete review of this literature). In this section, we consider an extended version of the model to assess the sensitivity of our main results with regard to this assumption.

In this extended model, we endogenize the fertility choices by simply assuming that the number of children directly enters into agents' utility function. Specifically, the second period problem facing agents becomes:

$$V_2(\psi, n^p, x^p) = \max_{c, a, n \geq 0} \left[\frac{c^{1-\sigma}}{1-\sigma} + \lambda_1 n^{\lambda_2} + \beta [V_3(x)] \right]$$

Table 8: Income-Fertility Relationship in the Endogenous Fertility Model

Ability Group i	1	2	3	4	5	6	7	8	9	10	11
ψ_i	0.02	0.04	0.09	0.21	0.46	1.0	2.19	4.81	10.56	23.16	50.80
Cumulative Mass	0.004	0.015	0.064	0.185	0.383	0.617	0.815	0.937	0.985	0.996	1.0
Fertility per Parent	1.62	1.40	1.35	1.35	1.24	1.15	1.15	1.07	0.95	0.85	0.85

subject to

$$c + a \leq \psi w(1 - \gamma n)$$

$$x = a + \frac{B(x^p)}{n^p}$$

Here agents derive utility from both current consumption c and the number of children they choose to have, n . λ_1 is the relative weight on the utility derived from children, and λ_2 controls the curvature of the utility from children.

To generate the negative income-fertility relationship observed in the data, we have to use a $\sigma \in [0, 1]$. Specifically, we set the value of σ to be 0.9. We calibrate the values of λ_1 and λ_2 to match the following two moments: the average fertility rate and the income elasticity of fertility. We calibrate the other parameters using the same moments as in the benchmark model. The fertility rates by each ability group are shown in Table 8. Our calibrated parameters are shown in Table 9.

The wealth distribution from the extended model is shown in Table 10. As can be seen, the main results remain very similar to those in our benchmark model, showing that our results are robust to the assumption of exogenous fertility.

Table 9: The Calibration of the Endogenous Fertility Model

Parameter	Value	Source
σ	0.9	Model Specification
β	0.92	annual interest rate: 0.04
ϕ_1	2.9	bequest/wealth ratio: 0.31
ϕ_2	0.07	pop. share with bequests (< half of income)
λ_1	0.712	Average Fertility Rate: 2.3
λ_2	0.369	Income-Fertility Elasticity: -0.21
σ_ψ^2	1.15	Income Gini: 0.63

Table 10: Wealth Distribution: Benchmark vs. Endogenous Fertility

Percentile	< 60%	60–80 %	> 80%	90–95 %	95–99 %	>99%	Gini Coef.
Benchmark Model	0.05	0.13	0.82	0.18	0.30	0.19	0.79
Endogenous Fertility	0.05	0.13	0.82	0.18	0.30	0.19	0.79

5.2. Relationship between Savings and Anticipated Bequests

A key implication of our model is that anticipated bequests have a crowding out effect on life-cycle saving, and thus there should exist a negative correlation between saving and expected bequests. In this section, we empirically test this implication. Specifically, we use the 2013 Survey of Consumer Finance dataset to estimate the cross-sectional relationship between savings and expected bequest.

The Survey of Consumer Finance data has information on both saving and anticipated bequests. For instance, it has a question asking how much they expect to receive from a substantial inheritance or transfer of assets in the future from their parents, and it has a question that asks how much they should have saved. We make use of the information

Table 11: SCF Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
β_1	-.023***	-.028*	-.034	-.035	-.023	-.028	-.033	-.035
S.E.	(.008)	(.015)	(.027)	(.045)	(.060)	(.077)	(.087)	(.159)
Bootstrapped S.E.	No	No	No	No	Yes	Yes	Yes	Yes
Sample	full	top 30%	top 10%	top 5%	full	top 30%	top 10%	top 5%

***-Significant at the 1% level

captured by these questions and consider the following regression specification:

$$a_i = \beta_1 \mathbb{E}[b_i] + \beta_q \chi_{iq} + \epsilon_i \quad (1)$$

where a_i is the individual i 's optimal amount of savings, and $\mathbb{E}[b_i]$ represents the expected bequests to be received in the future. In the regression, we also control for age, partners age, mother's age, partner's mother's age (second order polynomials), liquid assets, retirement accounts (IRAs, Pensions, etc), saving accounts, bonds, equity, total income (adjusted if an "abnormal year"), received inheritance in the past, race and education. These control variables are represented by the vector χ_{iq} .

Regression results estimating Equation (1) are shown in Table 11. Specification (1-4) of Table 11 is a basic OLS. Specification (5-8) uses a bootstrapping standard error technique with a correction for multiple imputation on our entire sample. Specifications (2-4) and (6-8) run on a subsample of top 30%, 10% and top 5% of the income distribution. The reason why we restrict ourselves to these subsamples is because almost all the bequests

observed in both the data and in our model occur within these subsamples. Even when the standard error is calculated correctly via bootstrapping, the point estimate is unchanged even though the statistical significance goes away. Overall, we document a fairly consistent negative correlation between savings and expected bequests, which corroborates what we found from our model.

6. Conclusion

This paper pursued two goals. First, to build and run a simple overlapping generations model including differential fertility and intergenerational transfers. We did this using a three period model with childhood, adulthood and retirement, where individuals evinced differential fertility and gave bequests to their children. Second, to match the wealth-income inequality disparity seen in the data, where wealth inequality is higher than income inequality. Although the wealth held by the top 1% from our model does not completely match the data, we come very close and match various other important moments. Overall, our results show that allowing differential fertility is crucial in explaining the disparity between the income and wealth inequality. In other words, we show that ignoring the fertility differences between the rich and the poor can only result in an incomplete picture of inequality. In addition, we find that expected bequests have a crowding out effect on life-cycle savings, which can be quantitatively important for understanding the wealth distribution.

We conclude the paper by drawing attention to a few potentially important issues from which this paper has abstracted. For instance, we have abstracted from government. This modelling strategy simplifies our analysis, and allows us to focus on the amplification effect

of differential fertility on the wealth distribution. However, government programs (such as Social Security) and fiscal policies would definitely have interesting distributional effects as well. In particular, these effect may interact with differential fertility and bequests. In addition, we do not model the human capital investment in children, and thus do not capture the well-known quality-quantity tradeoff of children facing parents. We leave them for future research.

7. Essay 2

This paper finds the quantitative wealth effects of adjusting or eliminating the estate tax in the United States. It also estimates the potential impact of switching from an estate tax regime to an inheritance tax regime. This paper's unique contribution is to examine these options in an environment of a general equilibrium, overlapping-generations model with differential fertility, using the wedge of fertility disparity between high- and low-earning individuals to more accurately capture the reality of intergenerational transfers.

Recent U.S. data shows large increases in the concentration of wealth over the past 3 decades. For instance, the top 1 percent holds nearly 1/3 of the total wealth in the economy, and that share is growing according to [Alvaredo et al. \(2013\)](#). The top 5 percent holds over 1/2 of the wealth. This trend has accelerated in the years since the 2008 financial crisis ([Saez and Zucman \(2016\)](#)). In addition, wealth inequality is significantly higher than labor earnings or total income inequality. In 1995, the Gini coefficient for annual labor earnings was 0.63. The Gini for wealth holding was much higher, at 0.8 ([Rodriguez et al. \(2002\)](#)). Understanding the causes for this relatively greater level of wealth inequality is important for the economic consequences faced by highly unequal economies, such as greater societal

unrest and lower intergenerational mobility.

Why is wealth inequality more pronounced than income inequality? This is a major puzzle surrounding the broader issues of inequality. Wealthy individuals act in a different way than traditional economic models would predict, relatively saving more and spending less, even as they reach the end of their lifespans (Dynan et al. (2004)). In addition to this, wealthier people are much more likely to give bequests to their children at the end of their lives, even when accounting for relative wealth. Standard dynamic models with heterogeneous agents have difficulty replicating this savings behavior. For instance, Aiyagari (1994) predicts in a calibrated simulation the top 1 percent will hold 4 percent of the wealth, while empirically the top 1 percent holds 30 percent. Why do the wealthiest people choose to possess such a high level of wealth instead of increasing their consumption?

One potential explanation for this behavior is a bequest motive, especially since intergenerational transfer is a significant flow of wealth. Historically, the amount of wealth derived from intergenerational transfer has varied between 1/10 and 1/5 (Modigliani (1988)), however, more recent estimates place it as high as 1/2 (Gale and Scholz (1994)). The bequest flow is highly unequal. The top 2% of households receive nearly 70% of lifetime inheritances (Hendricks (2001)).

Economists have argued there exists an inverse relationship between income and fertility.¹¹ For instance, Jones and Tertilt (2007) document a strong negative relationship between income and fertility choice for all cohorts of women born between 1826 and 1960 in the U.S. census data. They estimate an overall income elasticity of fertility for this time period of -0.38. I argue that this significant fertility difference between low and high earners

¹¹See De La Croix and Doepke (2003), De la Croix and Doepke (2004), Jones and Tertilt (2007), Zhao (2011), Zhao (2014), Cooke et al. (2017), among others.

can amplify the impact of bequests on wealth inequality, because not only do rich parents leave a greater amount of bequests than their poorer counterparts, but the children of richer parents tend to have fewer siblings to share their bequests with relative to the children of poorer parents.

If higher-earning couples have fewer children, as is consistently reported in the literature ([Jones and Tertilt \(2007\)](#)), this could significantly impact how transfer taxes are realized, and raises questions about which tax regime is most equitable and efficient. Transfers occurring at death may be taxed in the form of estate taxation, i.e. the tax may be imposed on the total amount of wealth left by the decedent. The taxes may instead take the form of an inheritance tax, in which case the base is defined on the level of the recipient, and reflects the transfers to that particular individual ([Kopczuk et al. \(2010\)](#)). Both forms of taxation usually have a supplemental gift taxation to ensure the tax is not simply avoided by a transfer given prior to the time of death. In the U.S. the gift and estate tax has been integrated since the Tax Reform Act of 1976.

The structure of the estate tax can lead to strange distortions in the progressivity of the tax burden. [Batchelder and Khitatrakun \(2008\)](#) estimate that about 22% of heirs burdened by the U.S. estate tax have inherited less than \$500,000, while 21% of heirs who inherit more than \$2,500,000 bear no estate tax burden. The quantity of heirs thus has a large impact on the distributional effect if the tax is progressive, as it almost always is. Many U.S. states and countries currently use an inheritance tax, such as Iowa, Kentucky, Maryland, Nebraska, New Jersey, Pennsylvania, Japan, France, U.K., South Korea and Germany. Understanding the impact switching from a federal estate tax to a federal inheritance tax could have on the United States wealth distribution is an understudied element of U.S. tax policy.

The role played in increasing wealth inequality by reductions in the estate tax over the past few decades remains contentious, and this paper will offer a quantifiable estimate as to the results of rate and exemption changes on the distribution of wealth. According to the Internal Revenue Service, in the past 17 years the top rate has fallen from 55% to 40%, and the exemption level has risen from 675,000 to 11 million for individuals. The number of taxable estates declined nearly 90 %, from 51,736 in 2001 to 5,219 in 2016, primarily due to the increases in the filing threshold (IRS SOI Tax Statistics). Clearly these changes are nontrivial and bear analysis. In addition, as the baby boomer generation begins to pass away, wealth transfers are expected to increase. Estimated transfers total between \$40 and \$135 trillion over the next half century according to [Havens and Schervish \(1999\)](#).

This paper will do the following. First, build and run an overlapping generations model that includes differential fertility, intergenerational transfers, and a comprehensive estate tax regime. Second, to scrutinize the impact changing rates and exemption levels would have on wealth inequality in a steady state analysis. Third, altering the model to switch to an inheritance tax and analyzing the results such a change would have on the distribution of wealth.

The rest of paper is organized as follows. In section 2, I review the existing literature. In section 3, I describe the model and its stationary equilibrium. In section 4, I calibrate a benchmark specification using moment matching. In section 5, I discuss the results. In section 6, I use alternative formulation to answer the core questions of the paper. The final section concludes.

8. Literature Review

8.1. Inequality and Bequests

Inequality and its causes have become a political and economic touchstone in recent years. However, defining what dimension of inequality is being considered is often left unsaid by the bumper stickers. There exists unequal distributions of productivity, income, wealth, consumption, bequests, shocks, choices, etc. Some of these elements, especially income and wealth, are treated as if they are equivalent. But the data shows large differences in the distributions of income and wealth in the United States. As found by [Diaz-Gimenez et al. \(1997\)](#), the correlations between earnings and wealth and between income and wealth are surprisingly low: 0.230 and 0.321, respectively.

In 1992 the United States' Gini indexes for short-term labor earnings, income, and wealth were respectively .63, .57, and .78 ([Diaz-Gimenez et al. \(1997\)](#)), while in 1995 they were .61, .55 and .80 ([Rodriguez et al. \(2002\)](#)). The shares of earnings and wealth of the households in the top 1 percent of the corresponding distributions are 15 percent and 30 percent, respectively ([Castaneda et al. \(2003\)](#)).

Standard quantitative macroeconomic models have had difficulties in generating the observed degree of wealth concentration ([De Nardi and Yang \(2016\)](#)). Specifically, these models fail to account for the extremely long and thin top tails of the distributions and for the large number of households in their bottom tails ([Castaneda et al. \(2003\)](#), [Quadrini and Ríos-Rull \(1997\)](#)). However, if it is intergenerational transmission of wealth and ability that drives wealth inequality, as [Kotlikoff and Summers \(1981\)](#) have argued, then a myopic focus on life-cycle saving will fail to capture the relevant causes of wealth inequality. Overlapping generations show an improvement at mimicking the data. Using an OLG model, [Huggett \(1996\)](#) predicts that the top 1 % will hold 7% of the wealth. This model only accounted for

accidental bequests, distributed equally to all individuals.

There have been multiple papers arguing that bequest giving is crucial to explaining wealth differentials. Most recently, [De Nardi \(2004\)](#), [De Nardi and Yang \(2016\)](#) and [Cooke et al. \(2017\)](#) incorporate bequest leaving into the utility function as a luxury good, allowing for rich parents to value bequests more. If bequests are a luxury good such that the rich gain greater utility from leaving them, then bequests will play an outsized role in generating wealth inequality. This is due to the emergence of large estates, or dynasties, where wealthy parents have well-educated, highly productive children to whom they leave large bequests. These persistent rich often have smaller families than the median, leading to greater relative concentration. This is consistent with [Jones and Schoonbroodt \(2010\)](#); smaller cohorts receive relatively large per child transfers from parents.

Bequests represent a large piece of intergenerational transfers. [Gale and Scholz \(1994\)](#) use the Survey of Consumer Finances to find the amount of inter-vivos transfers and inheritance from 1983-85. Between support given, college expenses paid, and inheritance given, the amount totaled over \$350 billion. Of this, inheritance was nearly 40 % and over 60 % of those who reported receiving inheritance were in the top decile of wealth. Their central estimate is that intended life-time transfers (which they define as inter-vivos transfers, trust accumulations, and life insurance payments to children) account for at least 20 % of aggregate net worth, and bequests, accidental or intended, account for 31 percent more. [Kopczuk and Lupton \(2007\)](#) find that 3/4 of the elderly single population has a bequest motive and about 4/5 of their net wealth will be bequeathed, half of which is due to a bequest motive as opposed to accidental bequests. This ratio is consistent with [Lee and Tan \(2017\)](#) and [Hendricks \(2001\)](#).

There are six widely discussed motivations in the economic literature surrounding intergenerational transfers ([Batchelder \(2009\)](#)). The first is an overabundance of precautionary savings, leading to accidental bequests. The second is commonly known as "money in the utility function": the wealth of an individual directly impacts her utility function, and therefore she will have a positive balance at the time of death. The third is "warm glow": the individual likes the idea of giving to their heirs, but the actual status of those heirs, or how much that transfer is taxed, is unimportant. The fourth is the same as the third, but the individual only gets utility from the warm glow giving post-taxation. The fifth is direct altruism, and the sixth is a strategic motivation, given for some compensatory action like old age care or social insurance. For computational ease, this paper will focus on the third motivation, following [De Nardi and Yang \(2016\)](#).

8.2. Taxation

Taxes on wealth transfer have been a common theme throughout human history. Early examples include 7th century B.C. Egypt and 1st century A.D. Rome. The first American wealth transfer tax dates from 1797. This was a simple stamp levy on receipts for legacies and wills. Since then, multiple inheritance taxes have been put into place as short term funding mechanisms, usually for wars ([Kopczuk \(2013\)](#)). The modern day incarnation of the estate tax dates from 1916, and is much more complex and wide-ranging. Today, nearly every member of the Organization for Economic Co-operation and Development has some form of estate or inheritance tax ([Gale and Slemrod \(2001\)](#)).

Despite this ubiquity, there is substantial debate around both the size of this tax and whether it should exist at all. Opponents decry the morbidity of taxing corpses and

the unfairness of "double taxation," as the recently deceased already paid taxes on their income before giving it to their inheritors. Conversely, supporters, ranging from liberals to libertarians, call large inheritances "affirmative action for the wealthy" (Stelzer (1997)). Transfer taxes have several unique properties (Kopczuk (2013)). First, the transfer may be generating positive externalities. For example, if the transfer is intentional, the giver will be generating utility (whether from warm-glow, altruism, or some other motivation), while the recipient is gaining greater income to finance their own utility-enhancing choices. Second it is infrequent, oftentimes occurring just once, at time of death. Finally, it only affects a small, wealthy subset of the population.

Stiglitz (1978) raises a major concern with the estate taxes effect on the economy. If the estate tax lowers savings, this will lead to a reduction in the capital stock and the marginal product of labor. In short, abolition of the estate tax could raise wages and lead to an improvement in welfare. Laitner and Juster (1996) find that Stiglitz is correct, and a lowering or removal of the tax on bequests would raise savings. However it would also increase wealth inequality, specifically among the top 1 % of the distribution who are most affected by the estate tax. This also does not take into account the finding in Cooke et al. (2017), that expected inheritances reduce savings among beneficiaries by around 3%.

Concern that estate taxes unfairly impact small business and farms has led to provisions allowing transfers of closely held businesses to value themselves at use value rather than the higher market value. They can also spread their tax burden across many years. In addition, the amount of small businesses affected by the estate tax is small. Farm assets and real estate were just 1.7 % of taxable estate value in 2000 according to the Internal Revenue Service. Limited Partnership and "other noncorporate business assets" were 2.6 %.

Even generous estimates of the definition of a small business results in them being about 1/10 of the total wealth transfer affected by the tax (Gale and Slemrod (2001)).

The last decade has seen major changes in the estate tax, with the basic exclusion amount rising from 675,000 in 2001 to 5.5 million in 2016 and 11 million in 2018. The top bracket tax rates also saw major changes, decreasing from 55 % in 2001 to 35 % in 2010, and then increasing to 40 % in 2013, according to the IRS. Understanding the mechanisms and effects of this tax policy is therefore very important.

9. Model

Consider an economy inhabited by overlapping generations of agents who live three periods. In the first period individuals are children who are not economically active. In the second period they make labor supply decisions, have children and save for retirement. In the final period they receive bequests from their parents, consume some of their wealth, and leave the remainder as bequests to their children in the next period. These bequests are taxed, and the tax is distributed equally among that cadre of children. This allows the estate tax to redistribute wealth within but not across generations.

9.1. Consumer's Problem

9.1.1. Period One

An individual makes no economic decisions in the first period, but imposes a time cost on her parents. She inherits an ability level from her parents. An individual's ability ψ (effective units of labor representing human capital, luck or inherent ability) depends on

their parental ability ψ^p , and the log of ability is assumed to follow an AR(1) process,

$$\log(\psi) = \rho \log(\psi^p) + \epsilon_\psi$$

where

$$\epsilon_\psi \sim N(0, \sigma_\psi^2), \quad \text{i.i.d.}$$

in which ρ is the intergenerational persistence of productivity. I discretize this into an 11-state Markov chain using the method introduced in [Tauchen \(1986\)](#), and the corresponding transition matrix I obtain is denoted by $M[\psi, \psi']$.

9.2. Period Two

Individuals in the second period differ along three dimensions: earning ability ψ , number of siblings n^p (or their parent's fertility), and current wealth of their retired parents x^p . In this period, they jointly choose current consumption and save for period three. In addition, they have n children, which is determined as a function of their ability level, and have to reduce their labor market allocation as a result of this allocation. Therefore, the value function of an individual in period two can be specified as follows:

$$V_2(\psi, n^p, x^p) = \max_{c, a \geq 0} \left[\frac{c^{1-\sigma}}{1-\sigma} + \beta [V_3(x)] \right]$$

subject to

$$\begin{aligned}
 c + a &\leq \psi w(1 - \gamma n) \\
 x &= a + \frac{B^p(x^p)}{n^p} - T(B^p(x^p), \tau, \chi, \kappa) + g \\
 n &= N(\psi)
 \end{aligned}$$

The individual can calculate an expected bequest value as a function of parental wealth and the number of siblings in the next period, $B^p(x^p)/n^p$, where $B^p(x^p)$ is the policy function for optimal amount of bequests given, dependent on wealth. Thus the total wealth the individual possesses going into period 3 is $x = a + B^p(x^p)/n^p - T(\cdot) + g$, where a is the life-cycle saving from period 2 to period 3 and n is number of children. $T(\cdot)$ is a tax payment on intergenerational transfers and g is a governmental lump sum transfer payment, the equally divided share of all taxes. The tax payment size depends on the size of the transfer being taxed, $B^p(x^p)$, the tax rate τ , the exemption level χ and the structure of the tax κ . In this model the structure can take the form of an estate or an inheritance tax.

9.2.1. Period Three

Individuals retire in the third period and jointly choose current consumption and the amount of bequests for their children. Their state in this period can be captured by a single variable, x , the amount of wealth held, which is simply the sum of life-cycle savings, the governmental transfer and the share of bequests received from their dying parents at the beginning of Period 3. Individuals in Period 3 face the following utility-maximization

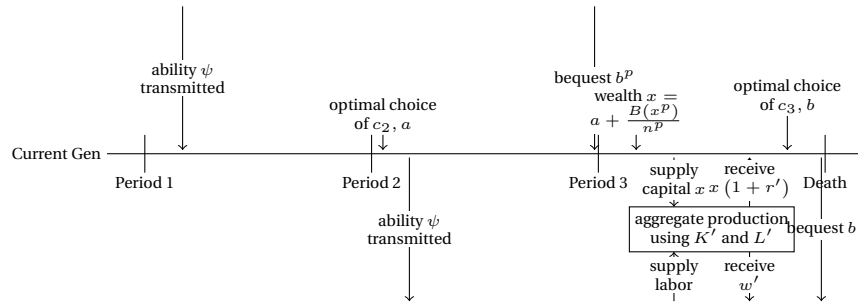


Figure 2: Sequence of Events for Current Generation

problem:

$$V_3(x) = \max_{c,b} \left[\frac{c^{1-\sigma}}{1-\sigma} + \phi_1 (b + \phi_2)^{1-\sigma} \right]$$

subject to

$$c + b \leq (1 + r)x,$$

where b is the total amount of bequests left for children in the next period. Here I follow [De Nardi \(2004\)](#) and assume that parents have “warm glow” motive, where they enjoy giving to their children but do not directly care about the children’s wellbeing, and the bequest is assumed to be a luxury good. The term ϕ_1 measures the relative weight placed on the bequest motive, while ϕ_2 measures the extent to which bequests are a luxury good. From this maximization problem, I obtain two policy functions: optimal consumption $C_3(x)$ and optimal bequests $B(x)$.

Figure 2 contains the timeline summing up the sequence of events that happen throughout the lifecycle.

9.3. Firm's Problem

Firms are identical and act competitively. Their production technology is Cobb-Douglas, which combines aggregate capital K and aggregate labor L to produce output Y as follows

$$Y = zK^\theta L^{1-\theta}$$

in which θ is the capital share and z is the total factor productivity (TFP).

The profit-maximizing behaviors of firms imply:

$$r = z\theta K^{\theta-1} L^{1-\theta} - \delta$$

and

$$w = z(1 - \theta)K^\theta L^{-\theta},$$

where δ represents the capital depreciation rate.

9.4. Government and Taxes

The government runs a balanced budget every time period. They levy taxes either on the estates of the deceased before distribution, or on the heirs directly, depending on whether it is an estate or inheritance tax.

Let Φ_2 represent the population distribution of individuals in period 2.

If there is an estate tax:

$$G = \int_{\psi} \int_{n^p} \int_{x^p} [(B^p(x^p) - \chi)(\tau)] d\Phi_2(\psi, n^p, x^p) \forall B^p(x^p) > \chi$$

and if there is an inheritance tax:

$$G = \int_{\psi} \int_{n^p} \int_{x^p} \left[\left(\frac{B^p(x^p)}{n^p} - \chi \right) (\tau) \right] d\Phi_2(\psi, n^p, x^p) \forall B^p(x^p) / n^p > \chi$$

and the individual payment g will be the equal distribution of all tax revenue.

$$g = \frac{G}{\int_{\psi} \int_{n^p} \int_{x^p} \Phi_2(\psi, n^p, x^p)}$$

In the benchmark model, the estate tax has a rate τ and an exemption level χ . All bequests below the exemption level are immune from taxation, all bequests above that level are taxed at a fixed rate on the amount above the exemption level.

This payment is distributed to the same generation that would have received the inheritance.

9.5. A simple comparison of the estate and inheritance tax

Consider a simple economy with 3 families: A, B and C. Family A has one child, family B has 2 children and family C has 3 children. In this economy there is an estate tax, with a rate and exemption level. In this example we will set both to 0.5. Each family's parents die,

Table 12: A simple example of the estate and inheritance taxes

Type	Rate	Exemption	A_1	B_1	B_2	C_1	C_2	C_3	Total Tax
Estate	0.5	0.5	0.75	0.375	0.375	0.25	0.25	0.25	0.75
Inheritance	0.5	0.25	0.625	0.375	0.375	0.29	0.29	0.29	0.75

leaving their children their remaining wealth, which is equal to 1 for all 3 families.

In this situation, all 3 families will pay the same amount in taxes, 0.25, and the remainder will be distributed to the children. So the child from family A will receive 0.75, the children in family B will receive 0.375 each and the children in family C will receive 0.25 each. The total government receipts amount to 0.75.

Let us now assume the tax regime switches to an inheritance tax with no changes to the rate or exemption level. Family A's tax burden will remain the same, but family B and C will pay no taxes because each child's share falls below the exemption level.

Then let us lower the exemption level to 0.25 so that the government receives the same amount of revenue. Now family A's only child is paying 0.375 in taxes and keeping 0.625, family B's 2 children are paying 0.125 each and keeping 0.375 and family C's 3 children are paying 0.04 each and keeping 0.29.

It is clear that the estate tax favors families with fewer children, which as we know are associated with higher-earning families.

9.6. Stationary Equilibrium

Let Φ_2 and Φ_3 represent the population distributions of individuals in period 2 and 3. A steady state in this economy consists of a sequence of allocations $[c_2, c_3, a, b]$, aggregate inputs $[K, L]$ and prices $[w, r]$ such that

1. Given prices, the allocations $[c_2, c_3, a, b]$ solve each individual's utility maximization problem
2. Given prices, aggregate capital and labor $[K, L]$ solve the firm's problem.
3. The Government's budget is balanced, $g = \frac{G}{\Phi_2(\psi, n^p, x^p)}$
4. Markets clear:

$$K' = \int_{\psi} \int_{n^p} \int_{x^p} \left[A(\psi, n^p, x^p) + \frac{B^p(x^p) - \tau(B^p(x^p) - \chi)}{n^p} \right] d\Phi_2(\psi, n^p, x^p)$$

$$L' = \hat{n} \int_{\psi} \int_{n^p} \int_{x^p} (1 - \gamma N'(\psi, n^p, x^p)) \psi d\Phi_2(\psi, n^p, x^p)$$

where \hat{n} is the average number of children the current period two individuals have to account for population growth.

5. The distributions Φ_2 and Φ_3 are stationary in the steady state and evolve according to the following laws of motions:

$$\Phi_2(\psi', n^{p'}, x^{p'}) = \frac{1}{\hat{n}} \int_{\psi} \int_{n^p} \int_{x^p} I_{x^{p'}=A(\psi, n^p, x^p) + \frac{b^p(x^p)}{n^p}} I_{n^{p'}=n(\psi)} M[\psi, \psi'] n(\psi) d\Phi_2(\psi, n^p, x^p)$$

$$\Phi_3(x^{p'}) = \frac{1}{\hat{n}} \int_{\psi} \int_{n^p} \int_{x^p} I_{x=A(\psi, n^p, x^p) + \frac{b^p(x^p)}{n^p}} d\Phi_2(\psi, n^p, x^p)$$

where $M[\cdot]$ is the Markov transition matrix, I 's are the indicator functions. In the third period, an individual's wealth is what he has saved in the previous period, as well as what he has received in bequests from his parents. Note that the distribution

of the wealth holdings is identical to the distribution of the next generation's parental wealth holdings (i.e., $x = x^p$).

The rest of the paper focuses on stationary equilibrium analysis. Since analytical results are not obtainable, numerical methods are used to solve the model.

10. Calibration

I calibrate the model to match the current U.S. economy, and the calibration strategy I adopt here is the following. The values of some standard parameters are predetermined based on previous studies, and the values of the rest of the parameters are then simultaneously chosen to match some key empirical moments in the U.S. economy.

10.1. Demographics and Preferences

One period in my model is equivalent to 30 years. Individuals enter the economy when they are 30 years old (Period 2). They retire at 60 years old (Period 3) and die at the end of the third period at 90 years old.

The subjective discount factor β is calibrated to match an annual interest rate of 0.04, which gives an annual discount factor of 0.915. I calibrate my bequest parameters to ensure that the level and distribution of bequests generated from my benchmark model matches their respective data counterparts. Specifically, ϕ_1 is calibrated to match the aggregate bequest to wealth ratio: 0.31 according to the estimation by [Gale and Scholz \(1994\)](#). A positive value of ϕ_2 implies that bequests are luxury goods, and its value controls the skewness of the bequests distribution. According to the empirical estimation by [Hurd and Smith \(2002\)](#), about 90% of the population does not leave a significant amount of bequests (i.e. less than

Table 13: The Benchmark Calibration

Parameter	Value	Source
z	1.0	Normalization
σ	1.5	Macro Literature
θ	0.36	Macro Literature
δ	0.04	Macro Literature
γ	0.2	Haveman and Wolfe (1995)
ρ	0.4	Solon (1992)
χ	5.5 million	IRS 2017
τ	0.4	IRS 2017
Parameter	Value	Moment to match
β	0.915	annual interest rate: 0.04
ϕ_1	-0.33	bequest/wealth ratio: 0.31
ϕ_2	0.086	pop. share with bequests (< third of avg. income)
σ_ψ^2	1.15	Income Gini: 0.63

a third of average lifetime income)¹². [Gale and Scholz \(1994\)](#) report that 96% do not receive inheritances above 3,000 dollars. In the benchmark calibration, I calibrate the value of ϕ_2 so that 90% of agents in the benchmark model receive bequests that are less than a third of median lifetime income.

I use the 1990 U.S. census data to calibrate the fertility choices for each group in my benchmark model¹³. I follow the approach in [Jones and Tertilt \(2007\)](#) and use "children ever born" as the fertility measure. Specifically, I use the sample of currently married women ages 40-50 (birth cohort 1940-50), and then organize the respondents into 11 ability groups

¹²In nominal terms, that value equals \$187,600 in 1993 dollars or \$324,700 in 2017 dollars.

¹³Courtesy of Steven Ruggles, Katie Genadek, Ronald Goeken, Josiah Grover, and Matthew Sobek. Integrated Public Use Micro data Series: Version 6.0 [dataset]. Minneapolis: University of Minnesota, 2015. <http://doi.org/10.18128/D010.V6.0>.

corresponding to my model distribution by occupational income, corrected for a 2% growth rate.¹⁴ The propensity of death on childbirth during this time period is low enough that the child mortality risk is not a significant issue. I take the mean fertility rate for each group and assign it to the corresponding group of agents in my benchmark model to generate the appropriate level of differential fertility by income.¹⁵ The resulting fertility-income relationship from my calibration exercise is reported in Table 15, which is consistent with the estimation results in Jones and Tertilt (2007). For instance, the income elasticity of fertility is estimated to be -0.20 to -0.21 for the cohorts of women born between 1940 and 1950 in Jones and Tertilt (2007), while the implied income elasticity of fertility from my calibrated fertility distribution is -0.22.

10.2. Technology and Earning Ability

The capital share θ is set to 0.36, and the capital depreciation rate is set to 0.04. Both are commonly used values in the macro literature. The value of TFP parameter, z , is normalized to one.

I approximate the AR(1) process for earning ability ψ by an 11-state Markov chain using the method introduced in Tauchen (1986). The coefficient of intergenerational persistence, ρ , is set to 0.4 according to the estimates in Solon (1992). I calibrate the income variance σ_ψ^2 so that the income Gini coefficient generated from the model matches the value of 0.63 that Castaneda et al. (2003) estimated using 1992 Survey of Consumer Finances data. I report the resulting ability levels in Table 15 and the corresponding transition matrix can

¹⁴Here I follow Jones and Tertilt (2007) closely and use the husband's occupational income to avoid the selection bias in the mother's employment status.

¹⁵Note that the fertility choice in my model is the per parent fertility so I follow the tradition in the fertility literature and halve these fertility rates calculated from the data when using them in the model.

be seen in Section ?? of the Appendix. In addition, I set the time cost of children γ to be 0.2 of parental time per child based on the empirical estimates of [Haveman and Wolfe \(1995\)](#).

The key parameter values and their sources are summarized in Table 13.

10.3. Taxation

The two taxation coefficients, τ and χ , are taken from the 2017 CFR 601.602: Tax forms and instructions. The section titled "Unified Credit Against Estate Tax" states "for an estate of any decedent dying in calendar year 2017, the basic exclusion amount is \$5,490,000 for determining the amount of the unified credit against estate tax under S2010." I combine this with table 5 - section 1(e) "Estates and Trusts" which states that the rate of taxation for estates greater than \$12,500 is "\$3,232.50 plus 39.6% of the excess over \$12,500."

This gives us an estimated value of τ of 0.4 and a value of χ of 5.5 million in my benchmark. Since my model is normalized, I set χ to match a multiple of median lifetime income, which I estimate as \$1,180,000 which is \$59,039 per household in 2017 (U.S. Census Bureau) times 40 years divided by 2 people. This means the 2017 estate tax exemption is 4.6 times the median lifetime income.

11. Quantitative Results

I start this section by reviewing the main properties of the benchmark model at the steady state, with special attention given to its implications for wealth inequality. I then run counter-factual policy experiments analyzing the abolition of the estate tax, an increase of the estate tax back to 2001 levels, and changing the structure of the intergenerational tax from a estate tax to an inheritance tax.

Table 14: Benchmark Model Statistics

Name	Model	Data
Annual Interest Rate	0.04	0.04
US Aggregate Bequest/Wealth Ratio	0.31	0.31
Average fertility rate per household	2.3	2.3
Gini Coefficient of the US Income Distribution	0.64	0.63
Income Elasticity of Fertility	-0.22	-0.20/-0.21

11.1. Some Key Properties of the Benchmark Economy

A key element of my theory is the negative income-fertility relationship, which is best measured by the income elasticity of fertility. The income elasticity of fertility implied by my benchmark model is very close to its empirical counterpart estimated by [Jones and Tertilt \(2007\)](#). Another important characteristic of my model is the skewed distribution of bequests with a long right tail. I ensure the model matches the bequest distribution I observe in the data by modelling bequests as luxury goods in the fashion of [De Nardi \(2004\)](#) and [De Nardi and Yang \(2016\)](#). In addition, my calibration strategy implies that my benchmark model matches the bequest-capital ratio and the 90th percentile of bequest amount.

Table 14 contains some key statistics of the benchmark economy together with their data counterparts. As can be seen, my calibrated benchmark model matches the key empirical moments from the US economy fairly well. Table 15 summarizes the ability distribution generated by my benchmark model, along with how the average fertility calculated by ability groups match up against the data. The first row represents the relative value of the ability ψ_i for Group i , in which the value for Group 6 is normalized to unity. The second

Table 15: Fertility-Income Relationship from the Benchmark Model

Ability Group i	1	2	3	4	5	6	7	8	9	10	11
ψ_i	0.02	0.04	0.09	0.21	0.46	1.0	2.19	4.81	10.56	23.16	50.80
Cumulative Mass	0.004	0.015	0.064	0.185	0.383	0.617	0.815	0.937	0.985	0.996	1.0
Fertility per Parent	1.6	1.6	1.4	1.4	1.24	1.15	1.08	1.07	0.96	0.86	0.89

Data source: 1990 U.S. Census

row is the share of the population whose ability is equal to or less than that group. Hence, Group 11—the highest ability group in my model—corresponds to the top 0.4% and the top two groups together correspond to the top 2% of the population. Of special note is Groups 8 through 11, as these are the ones that give almost all bequests in the economy.

12. Counterfactual Models

In order to determine the impact of the taxation regime that I have instated in this model, I run several counterfactual models. All these models are recalibrated to match the bequest wealth ratio, the 90th percentile of bequest moment, the average fertility and elasticity of fertility, the interest rate and the Gini coefficient of the income distribution. They institute different exemption levels, rates and structures to the intergenerational transfer tax. In all cases the tax that is levied continues to be distributed equally to all members of that generation as a lump sum transfer.

12.1. No Estate Tax

The first counterfactual model attempts to ascertain the quantitative effect of abolishing the estate tax. In this model the tax rate is set to zero, so no estates pay taxes no matter how large. No government revenue is generated. No transfer payments occur.

12.2. 2001 Estate Tax

The second counterfactual model changes rates and exemption level to match the estate tax law in 2001. This means a top rate of 55% and an exemption level of \$675,000. This is an exemption level that is 1/8 the exemption level of the benchmark. The higher rate and lower exemption level will generate larger government revenues and the transfer payment outlays will be larger as a result.

As with the benchmark model, this is an overstatement of the actual affects of the estate tax, as there are numerous avoidance strategies allowing individuals to not pay their full tax burden that this model does not take into account. However this alteration to the intergenerational transfer tax will generate much larger lump sum payments from the government. It will also result in a significantly smaller amount of bequests that are received by the children of the top few percentiles. This will result in a less extreme wealth distribution.

12.3. Inheritance Tax

The final counterfactual model will replace the estate tax with an inheritance tax. The rate will remain at 55%, and the exemption level is calibrated to match the total government revenue from the 2001 case. I chose 2001 as more individuals were affected by the tax and therefore the comparison will be more clear cut. This means the the transfer payment from the inheritance tax will be identical to the transfer payment in the 2001 estate tax case. The only difference is that a larger burden will fall on families with fewer children and a lighter burden will fall on families will more children relative to the estate tax.

This is because the inheritance tax will calculate the tax payment after the parental bequest is divided among their children. If there are more children, the amount received by

each child is smaller, and they are more likely to be receiving an amount that is below the exemption level, or, if the amount is still above the exemption level, less of it will be taxable. As the rate remains the same as in the estate tax case, this will result in a direct increase in tax burden to families with fewer children and a decrease to families with more children.

13. Distributionary Effects

In this section, I examine the distributions generated by my benchmark model and compare them to the counterfactuals. I analyze the distribution of wealth, savings and bequests and mine these results for insights on the impact of fertility and transfer taxation on distribution of wealth.

The wealth distribution in this model is untargeted, and gives me a method to evaluate how the model does with replicating the actual distribution of wealth in the United States, as well as allowing me to evaluate the different counterfactuals against each other with regards to their impact on the wealth distribution.

13.1. Benchmark Wealth Distribution

I compute the proportion of overall wealth held by each percentile group in my benchmark model and compare it against the data. It is important to remember that these statistics of the wealth distribution are not used as my targeted moments in the calibration. Some key statistics of the wealth distribution are reported in Table 16.

Overall my model does a moderately accurate job of matching the actual distribution of wealth in the U.S., especially among the top 20%. As can be seen in the last column of Table 16, my benchmark model matches the Gini coefficient of the wealth distribution closely.

Table 16: Wealth Distribution

Percentile	< 60%	60–80 %	> 80%	90–95 %	95–99 %	>99%	Gini Coef.
Data	0.08	0.13	0.79	0.13	0.24	0.30	0.78
Benchmark Model	0.05	0.15	0.80	0.18	0.29	0.16	0.77
No Estate Tax	0.04	0.13	0.82	0.18	0.30	0.19	0.79
2001 Estate Tax	0.09	0.14	0.77	0.18	0.27	0.16	0.74
Inheritance Tax	0.10	0.15	0.75	0.17	0.27	0.15	0.71

Data source: [Diaz-Gimenez et al. \(1997\)](#)

The Survey of Consumer Finance data shows the top 20% holding 79% of the data, while my model predicts they will hold 80%. The data shows the top 10 and 5% holding 67 and 54% of economic wealth respectively. My model predicts these values to be 68 and 45%. As the distribution moves into the extreme right tail of the distribution, my model has a harder and harder time matching the high degree of wealth concentration.

The richest 1% from my benchmark model hold significantly less wealth than the data. My model predicts they will hold 16% of the wealth, while in the data they hold 30%. Clearly there is additional wealth concentrating mechanisms not present in my model. Potential explanations not modeled here are preventative savings for income shocks, entrepreneurship, and preference heterogeneity. However, using only intergenerational transfer of wealth and fertility differentials does do much better at matching the data than traditional macroeconomic calibrated simulations that predict the top 1 percent will hold 4 percent of the wealth ([Aiyagari \(1994\)](#)). This indicates the importance of these two mechanisms, and indicates that fertility, a mechanism typically overlooked by macroeconomic simulations, is a crucial piece of the puzzle for explaining wealth inequality.

13.2. Counterfactual Wealth Distribution

13.2.1. No Estate Tax

Comparing my benchmark to the counterfactuals yields some interesting observations. As expected, abolishing the estate tax increases overall inequality. Specifically it increases the wealth holding of the top 1% by 12% and the wealth holding of the top 20% by 2.5%. This is notable because very few individuals are actually paying estate taxes and they are clustered at the far end of the right side of the wealth distribution. So outside the extremely rich, few were affected by the estate tax. Abolishing the estate tax therefore has an outsize impact on the wealth distribution because it is such a targeted tax.

The other major impact of abolishing the estate tax is the removal of the transfer payment. While the size of the payment was small (roughly \$3000 per person in this model's benchmark calibration, or less than \$100 per year), it was helpful to less wealthy individuals. Consequently the wealth holding of the bottom 80% decreases slightly as a result.

13.2.2. 2001 Estate Tax

The 2001 estate tax level has a much lower exemption (about one eighth) than the benchmark model. In addition it has a higher rate, .55 from .4. This means a larger amount of individuals will have to pay the tax, as well as the individuals already affected paying a much larger share. The impact of this is that the impact on the wealth distribution is no longer felt solely by the super rich. The top 1% drop their share of wealth from the benchmark model by 6% and the top 20 drop by 4%.

Comparing the 2001 estate tax counterfactual to the no bequest counterfactual yields even more extreme results. Abolishing the estate tax from 2001 levels increases the wealth

holdings of the top 1% by 19% and the top 20% by 6%. While the estate tax affects relatively few households, the fact that it affects the extremely rich means that its wealth distributional influence is significant. In addition, the transfer payment increases, and the wealth holdings of the lower percentiles correspondingly expands. The bottom 60% nearly double their wealth holdings as a percentage of the total wealth in the economy, which is a combination effect of the wealthy's bequests being taxed more heavily and the less wealthy benefiting relatively more from the increased transfer payment.

13.2.3. Inheritance Tax

The inheritance tax also leads to a drop in wealth inequality. This is because in the model, lower ability individuals have more children. So given an equally sized bequest, the children of lower ability individuals (who are themselves more likely to be lower ability) will pay relatively lower taxes on their inheritance than the children of higher ability individuals. I am looking at this transfer from the perspective of the recipients of the bequests.

However, because lower ability individuals rarely give large bequests in this model the main influence of the taxation regime switch is the transfer of the tax burden from the 90% percentile to fall more heavily on the top 1%. While the fertility differences between these two groups is not large (around .4 children per household) the aggregate effects are significant. I see a decrease in the wealth holding of the top 1% by around 6%, and a decrease in the Gini coefficient of wealth by 4% when compared to the estate tax that generates the same amount of revenue.

This leads to a crucial conclusion of this model. The structure of the intergenerational transfer tax has a major impact on where the tax burden lies and the corresponding impact

of the tax on wealth distribution. Models that do not acknowledge the fertility differential between different earning levels will miss this insight.

13.3. Bequests

I compute the proportion of overall bequests made by each percentile group in my benchmark model and compare it against the data. Some key statistics of the bequest distribution are reported in Table 17.

The bequest distribution comparison between the benchmark and the counterfactual models is largely what would be expected. Abolishing taxes increases the bequest share of the top 1% by nearly 30% compared to the benchmark model. As the tax rate is increased and exemption lowered to the 2001 counterfactual model, the share of the top 10% also drops by 4%, as more and more individuals have to pay the estate tax, and the tax on the amount in excess of the exemption is increased by 37.5%.

Changing to an inheritance tax does not alter the distribution of bequests very much, though there is a slight drop in the bequests received by the top 1%. This is intuitive, as the top 1% have the lowest number of children and would be more relatively effected by an inheritance tax. It is important to remember that there is high persistence of ability (and therefore wealth) across generations, so the highest ability individuals tend to have fewer siblings.

13.4. Savings

I compute the proportion of overall savings chosen by each percentile group in my benchmark model and compare it against the data. The savings distribution for my bench-

Table 17: Bequest Distribution

Percentile	< 90%	90–95 %	95–99 %	>99%	Gini Coef.
Benchmark	0.01	0.29	0.40	0.30	0.93
No Estate Tax	<0.01	0.13	0.47	0.40	0.96
2001 Estate Tax	0.05	0.20	0.43	0.32	0.93
Inheritance Tax	0.05	0.23	0.42	0.31	0.93

Table 18: Savings Distribution

Percentile	< 90%	90–95 %	95–99 %	>99%	Gini Coef.
Benchmark	0.41	0.13	0.27	0.19	0.75
No Estate Tax	0.42	0.14	0.26	0.18	0.72
2001 Estate Tax	0.37	0.17	0.28	0.19	0.75
Inheritance Tax	0.33	0.15	0.31	0.23	0.81

mark is reported in Table 18, as well as the savings distributions for each of my counterfactual extensions.

The savings distribution reveals the impact of transfer payments and bequests. Because these both increase an individual's wealth as they enter retirement, an individual saves less as a result, and increases consumption in the first period. This means that raising the estate tax actually increases the savings share of the top 1%. Of special note is the inheritance tax, which increases savings among the top of the distribution. This is because these individuals are receiving a lower amount of bequests after taxes and therefore save more as a result.

14. Conclusion

This paper pursued three goals. First, to build and run a simple overlapping generations model including intergenerational transfers and a simple representation of the estate tax. I achieved this using a three period model with childhood, adulthood and retirement, where individuals chose differential fertility and gave bequests to their children. Second, to match the wealth-income inequality disparity seen in the data, where wealth inequality is higher than income inequality. My result match this disparity, though it must be noted that I am unable to match the wealth level held by the top 1%. Finally, to quantitatively analyze the policy experiment of switching from an estate tax regime to an inheritance tax regime. I did this, and showed a switch would generate a more equitable distribution of wealth. Overall, my results show that the estate tax exemption levels and rates have an outsized affect on inequality for how few household are affected.

I conclude the paper by drawing attention to a few potentially important issues from which this paper has abstracted. This paper simplifies the life-cycle savings process. A model with a larger number of time periods and income shocks would generate greater variance in life-cycle savings and thus more wealth inequality. This model also simplifies the bequest motive and how it interacts with taxes. I intend to pursue a more nuanced model in future research.

15. Essay 3

Do private labor market conditions have an effect on the observable quality of teachers hired, and subsequent student outcomes? Economic theory suggests the answer is yes. If

lower variation in salary and therefore less reward for quality work are attributes of public sector jobs, then public sector workers are negatively selected. Bonin, et al. (2007) show occupational sorting matching low-aptitude applicants with low-earnings-risk professions. During a recession, the reduction in private sector salaries erodes this negative selection, causing an inflow of higher quality individuals from the private to the public sector.

The two research questions this study proposes to answer are:

- Do recessions cause worker migration from the riskier private sector into the relatively acyclic public sector?
- Are individuals hired during slack labor markets fundamentally different from those hired during robust labor markets, as measured by observable results and ability scores?

In this paper I show that individuals are responsive to recessions. Research has shown recessions have major long term effects on individuals entering the labor force (Oreopoulos, Wachter, Heisz, 2006). While past research has explored individuals upgrading their skills during recession, this paper instead focuses on occupational migration. During an economic downturn the probability density function of private sector wages faced by job-seeking individuals will shift, while education hiring will remain relatively stable, as demand for public sector workers is more acyclic than private sector workers (Berman and Pflieger, 1997). This shift will change the expected wages offered relative to other professions, without changing the local underlying political and cultural characteristics determining wage level. Recessions effectively raise the relative expected wage exogenously.

The major contribution of this paper is to analyze the effect of labor market conditions on the quality of new hires. In this paper I use primary and secondary level teachers as

the quintessential example of public sector workers to test the hypothesis that quality of hires increases during times of slackness. Using American Community Survey data, this paper shows a novel result: there are differing effects of recession on job market sorting for college graduates with education and non-education undergraduate degrees. I show evidence that non-education majors increase entry into the teaching profession when a recession occurs as they are entering the labor market for the first time. This is an important result, as teacher quality has been shown to be a key input in student achievement and economic outcomes (Chetty, Friedman, Rockoff 2015), and a policy with higher levels and variation in teacher salary could duplicate this recession effect.

Additionally, this paper matches two data sources, the NBER US Business Cycle Expansions and Contractions, and administrative data from North Carolina, to uniquely analyze the direct effect of labor market conditions on the quality of teachers as measured by their certification test score. This paper finds that 5th grade and Algebra II teachers hired during a recession score better on the math section of the certification exams by about 0.1 standard deviation.

Finally, I follow a working paper by Nagler, Piopiunik and West (NBER Working Paper No. 21393) and examine the effect of recession on standardized test scores. I use value added testing as a metric for student outcomes.¹⁶ I draw on data of both elementary and high school teachers. Nagler, et al. find that 5th grade teachers who are hired during a recession have on average 0.08 of a standard deviation higher math value added than non-recession teachers. My result is smaller, 0.04, but still significant. I also find that Algebra II teachers hired during a recession have improved value-added scores of 0.07 standard

¹⁶Chetty, et al. (2015) offer substantial justification for using value added metrics as a measure of student outcomes

deviations.

This rest of this paper is organized into five sections. In the first I look at recession as a motivator of labor market decision making. Specifically, I scrutinize whether recession impacts the decision to become a teacher, and if so, whether this affect is different for individuals who received a bachelor's in an education-related field compared to those who received a bachelor's in a non-education related field. In the second and third sections, I look at the effect of recession on observable measures of teacher quality. First, I use the teacher's own test scores on a certification test. Second, I use students' test scores on a state-mandated standardized test to generate a calculated measure of value added for each teacher. The fourth section contains falsification tests, balancing tests, and tests of differential attrition. The fifth section concludes.

15.1. Literature Review

Heterogeneous occupational earnings and separation risk have a major impact on worker characteristics. Murphy and Topel (1987) and Moore (1995) find professions with higher unemployment and earnings risk are compensated with higher wages. Hartog, et al. (2003) extends this to find higher wages are also linked to higher earnings variability. Individuals who accept riskier, more variable jobs are compensated for their uncertainty. Conversely, individuals who work safer jobs, such as those in the public sector, are paid relatively less. Bonin, et al. (2007) and Fouarge, Kriechel, and Dohmen (2014), identify risk-inclined individuals and find they sort into riskier professions. Risk-adverse individuals will instead choose lower-risk jobs that tend to be lower paid.

During recession this orderly sorting is disrupted. Not only will many occupations (par-

ticularly in the private sector) see large spikes in risk, but Moscarini and Vella (2008) find a large increase in noise as workers enter jobs less suited for their level of risk desire. They also find that occupational mobility declines with age, family commitments, and education. However, during recession this decline is weakened, and is reversed for college graduates. I find part of this occupational mobility is high quality individuals moving from the private to the public sector.

The relationship between government employees and the private labor markets grew in prominence during the years following the Great Recession. Relatively stable public sector pay in the face of a weak job market has become a subject of considerable contention, and the interconnected role of unions, especially teacher's unions, has been pivotal in political battles at the national, state, and local level.

At the core of this debate is whether public sector employees are fundamentally different from private sector employees. The literature has shown public sector workers, including teachers, face different incentive structures from the private sector and are influenced by a variety of factors not seen in private labor markets. Brueckner and Neumark (2014) find a relationship between public sector wage differentials and local amenities. They find public sector workers are relatively better paid in areas with amenities difficult to duplicate elsewhere, such as climate or skill density. They also find that the strength of public sector unions exacerbate this effect. As teachers are one of the largest groups of public sector workers, this finding is indicative of a close link between non-performance-related attributes and salary. Diamond (2015) also finds a great deal of responsiveness of public sector workers to their economic climate. Inelastic housing supply raises local governments' tax revenue and public sector workers capture a share of these rents either through

increased compensation when formal collective bargaining is legal or by increased corruption when collective bargaining is outlawed. Boiled down, when the disciplining effects of taxpayers' voting with their feet through migration are mitigated, government workers benefit (Freeman 1986).

Teacher unions have been found to have substantial effects on teacher salary. Barrow and Rouse (2004) find large school districts tend to overspend more than small ones. Rose and Sonstelie (2010) find the power of teacher's unions rises with the number of eligible voters in a district, with power measured by the pay premium given to experienced teachers. Brunner and Squires (2013) show leaders of more powerful teacher unions are able to bargain for more generous returns to teacher seniority, to the detriment of staffing ratios and base salaries. These papers indicate that teacher salary is determined by a variety of factors not related to teacher quality, but rather a variety of political and environmental causes. This casts doubt on whether public sector workers are responsive to the same incentives vis-a-vis salary as private sector workers.

Teaching is a more stable profession than many private sector jobs, but offers less opportunity for wage growth. Wage dispersion has been rising at a faster rate in private sector jobs than in public sector jobs since the 1970s (Borjas 2002). This relative change in the wage structure influences labor supply decisions, and alters worker sorting between the two sectors. This alteration has led to high-skilled workers such as college graduates avoiding the public sector, while high-skilled public sector workers have increased incentives to leave for a private sector job. This paper does not attempt to answer what the determinants of public sector pay are, but rather argues that national recessions can be taken as exogenous shocks to wage structure, thus attempting to sidestep the endogeneity of salary

determination. Demand for teachers is more acyclic than the private sector (Berman and Pfleeger, 1997). Several types of analyses show that teachers earn significantly less than comparable workers in the United States (Allegretto, Corcoran and Mishel 2004). Rickman, Wang and Winters (2015) find relative wages significantly impact the choice to enter the education field. They compute public school teacher salaries for comparison across U.S. states and find that state differences in federal tax-adjusted teacher salaries relative to those of other college graduates significantly affects the share of education majors employed as teachers. If there is an increase in individuals seeking teaching jobs when relative salary increases, recessions should increase numbers of applicants for teaching jobs. However, no paper has directly documented individuals sorting into teaching during recessions.

Job seekers respond to incentives, and recession serves to lower their reservation wage by increasing the amount of effort it takes to search for a job. This increases the likelihood that job-seekers will accept a job with a relatively lower wage, like an American teacher (Borjas 2002). Recessions have negative long term effects on individuals entering the labor force, impacting salaries and opportunities long after the recession has passed (Oreopoulos, Wachter and Heisz, 2006) as well as future job mobility (Neal 1999). Personal attributes have been found to drive occupational sorting; as Fouarge, Kriechel and Dohmen (2014) show, individual risk appetite and patience has a large impact on career choice, and a mismatch between personal predilections and career choice increases probability of career migration.

My paper is the first to directly document a link between recessions and teacher test scores.¹⁷ Salary differentials can be a result of an endogenous political or cultural pro-

¹⁷Figlio (1997), Dolton and Holloway, (2011) or Hanushek, Piopiunik, and Wiederhold (2015) show the rela-

cess. Researchers need to find an alternate exogenous cause of teacher salary change. This paper's identification strategy uses national recessions to fulfill this purpose, as a national recession is unrelated to local political machinations. If the prevailing economic climate is poor, individuals entering public service may experience unwelcome competition from unemployed private sector workers, boosting the quality of the individual hired on average. This paper uniquely contributes to the literature by showing that teacher quality is impacted by economic recession.

16. Labor Market Inquiry

16.1. Data

I estimate a model using data from the National Bureau of Economic Research and the American Community Survey, courtesy of the Integrated Public Use Microdata Series. This regression looks at the effect of market conditions on the industry in which a student finds employment.

In this regression, I wanted to explore the question of what happens to graduates when recession occurs after they graduate with a bachelor's degree. Since the late 1990s, states have relaxed certification processes to allow individuals with bachelor's degrees not in the field of education to become teachers. This regression attempts to see if more of them enter the teaching profession during recessions.

I obtained American Community Survey data on 365,520 college graduates over age 18 and under the age of 28 at the time of census (to reduce occupation and location migra-

tionship between nationwide cognitive skill tests or relative teacher salaries and student outcomes.

tion, as well as to avoid respondents who had experienced multiple recession periods¹⁸) gathered between the years 2009 and 2014 using IPUMS. Using data from the National Bureau of Economic Research, I matched them to a recession dummy. The recession dummy is taken from the NBER's Business Cycle Dating Committee. It is coded as 1 if a national recession begins or is ongoing in that year. I did not use local recession or employment data as that would introduce the confounding possibility of labor mobility, which my data set is not equipped to handle.

Table 1 contains summary statistics on a selection of races, gender, age, and undergraduate field of study. Education degree holders are disproportionately female, and are more likely to currently hold a job than individuals with a degree from a different field.

16.2. Empirical Methods

I then estimated the following fixed effect linear probability regression with clustered errors by state.

$$FieldofOccupation_{ist} = \alpha_s + LaborDummy_{ti} + \beta_1 RecessionDummy_{ti} + \beta_2 \chi_i + \epsilon_i$$

where Field of Occupation for person i , in state s and at time t is the field the person declared as their occupation in the ACS. It is an indicator variable that is one when the field is education related, and zero when it is not. This includes postsecondary teachers, preschool and kindergarten teachers, elementary and middle school teachers, secondary school teachers, special education teachers, and other education, training, and library workers. The labor dummy is a control variable that takes a value of 1 when the individual

¹⁸For instance, an individual who is 28 during 2008, a recession, was 21 during 2001, a recession, and that recession may make them more likely to seek a teaching degree, and give a false signal about recessions at age 28.

is currently in the labor force at the time of the survey. α_s is the state fixed effect. χ_i is education degree, census year, gender and ethnic controls. The ethnic dummies include White, Black/Negro, American Indian or Alaska Native, Chinese, Japanese, other Asian or Pacific Islander, other race, two major races and three or more major races. ϵ is an error term.

16.3. Results

I ran the regression with a recession dummy for ages 22-24. I also ran a separate regression for ages 19-21 to act as a falsification test. Standard error is adjusted for 51 clusters by state and D.C.

Results are reported in table 2. Each cell is a separate regression. The dependent variable is a dummy that takes the value of unity when the individual works in an educational occupation. The rows are different age during recession dummies, and the columns are different subsamples depending on the type of degree the individual graduated with. I include the same ethnic, labor force and gender controls for every regression. For example, the coefficient reported for the first regression is an independent dummy variable with value unity for the people who turned 19-21 during a recession (so birth cohorts 1987-1989).

The effect of recession after graduation was significantly positive only for individuals who do not hold an education degree, and has an effect of 0.09 percent. It is insignificant for education degree holders. This would indicate that recession is a motivator for non-education degree holders to enter the teaching profession. I include recession before graduation to act as a falsification test and find no significant results.

Something to note is that this dataset does not pass balancing tests, as the observables

of college graduates change depending on the cohort. To this end I also ran a regression looking only at individuals graduating college before and during the Great Recession, and excluding those who graduated after 2009. My result is still significant, though the coefficient is lower at 0.06 percent. In this subsample the observable characteristics of college graduates do not change as a result of the recession, and I pass balancing tests on those observables. I follow this practice of comparing recession affected individuals only to pre-recession individuals (and not post) in the later two sections.

17. Teacher Test Scores Inquiry

In this section I run two regressions. The first looks at the effect of labor market conditions on observable teacher ability, measured by teacher qualification exams. The second replicates Nagler, et al. using data from a different state and extends their work to high school students.

17.1. Data

All student and teacher data was provided by the North Carolina Education Research Data Center (NCERDC). The North Carolina Education Research Data Center is a unique portal to a store of data from the North Carolina Department of Public Instruction (DPI) and the National Center for Education Statistics (NCES).

Using data on years of teacher experience, I match teachers to the year in which they were hired, then matched their year of hire to whether there was a recession in that year. The recession dummy is taken from the NBER's Business Cycle Dating Committee. It is coded as 1 if a national recession begins or is ongoing in the year in which the teacher

entered their profession. Local recession or employment data was not used as that would introduce the confounding of labor mobility, which my data set is not equipped to handle. I was also able to obtain whether a teacher had earned a master's degree and included this as a control variable.

My data set included the Praxis teacher examination scores for a subset of the teachers being considered. To my knowledge the effect of the labor market conditions on teacher test scores has not been estimated.

I ran a regression to estimate this effect:

$$TeacherTestScore_j = \beta_0 + \beta_1 RecessionDummy_{jt} + \beta_2 TeacherControls_j + \beta_3 YearFixedEffect_t + \mu$$

The variable of interest is a dummy variable that is 1 when a teacher is hired during a recession and 0 otherwise.

I was able to match 441 Algebra II teachers and 3700 5th grade teachers to the Praxis math test. This is fewer than the subsequent Value Added analysis due to the test not being recorded prior to the early 90s and the fact that teachers may have taken an alternative certification test. The Praxis test included is the Pre-Professional Skills Test (Math score). When teachers had taken multiple tests I kept only the score from the first test taken. There is no reason to think that the teachers matched are more or less susceptible to labor market conditions at time of hire, so the estimate will remain unbiased. I normalized teacher test score to have a mean of zero and a standard deviation of one. Teacher controls include gender and ethnicity. Summary statistics are detailed in Table 3. Teachers are predominately

female. Standard errors are clustered by hire year. Results are reported in Table 4. The two columns are for 5th grade teachers and Algebra II teachers respectively. I also run this regression only on teachers hired during a recession or 5 years previous to a recession, to match my labor sorting regressions and to ensure I am getting a clean comparison between individuals hired in the zenith and nadir of the business cycle.

17.2. Results

I find that 5th grade teachers hired during a recession scored significantly better than teachers not hired during a recession. 5th Grade recession hires scored 0.107 standard deviations higher and Algebra II teachers scored 0.114 standard deviations higher. This lends credence to my theory that these are individuals of higher academic ability driven into the teacher profession by a slack job market. The recession plus 5 years previous subsample shows similar results, though my 5th grade coefficient becomes weaker.

18. Teacher Value Added Inquiry

I follow Nagler, Piopiunik and West as closely as possible. First I construct a measure of teacher value added using 3rd, 4th and 5th grade test scores from over 2 million North Carolina students between 1995-2011. I then use the same techniques on a group not considered by Nagler, et al: High School Algebra students. Using math scores from 8th grade as well as Algebra I and II standardized scores, I use the same model to evaluate labor market conditions on student outcomes.¹⁹

¹⁹Historically the measurement of student outcomes has been contentious. While a good teacher can have a profound impact on learning outcomes, evaluating teachers has lead to a great deal of controversy, as the validity of commonly used value added metrics has been called into question. "High stakes tests" adds to stress faced by students and teacher retention and pay resulting from their value added metric has added additional pressure to these examinations. Chetty, Friedman, and Rockoff (2014) offer support for the effectiveness of

18.1. State Comparison

While Nagler, et al. use administrative data from Florida, the data in this paper comes from North Carolina. Using information obtained from USC Rossier, Table 6 compares and contrasts key statistics in each state. The two states are largely similar, though Florida pays its teachers more, North Carolina has a slightly higher wage relative to the average wage in the state. Both states allow lateral entry.²⁰ To become certified as a teacher in Florida, an individual needs to complete a number of college credit hours, a teacher preparation course, and Florida General Knowledge Test and the Florida Subject Area Examinations. Certification testing in Florida is run by FTCE (Florida Teacher Certification Examinations), and is specific to Florida. North Carolina uses the standard Praxis Pre-professional Skills Test (PPST), along with subject specific tests (Praxis II). States offer alternative licensure programs for teachers who do not have the experience required for a traditional license. This is an alternate route to teaching for individuals outside of the public education system.

a using value added evaluation to estimate student outcomes. Their paper looks at elementary and middle school teachers who have substantially improved the standardized test scores of their students. They found that students assigned to high value added teachers are more likely to attend college, less likely to experience teen pregnancy, and earn higher salaries. These high value added teachers are correlated with a lasting positive effect on those students' lives beyond academics. Chetty, et al. tracked 2.5 million students over 20 years. Replacing a teacher whose value added measurement is in the bottom 5 percent with a teacher from the center of the value added distribution would increase the present value of students' lifetime income by approximately 250,000 dollars per classroom. Rivkin, Hanushek and Kain (2005) find that improving teacher quality, as measured by student test scores, one standard deviation has the same effect as reducing classroom size by ten students. Hanushek (1992) shows that high quality teachers can obtain a gain of 1.5 grade level equivalents while a poor teacher will only accomplish 0.5 grade level equivalents during an entire academic year of teaching. The evidence suggests that there is teacher level heterogeneity that leads to dramatic differences in student outcomes. If the teacher is important, then improving the teacher is a surefire way to improve student outcomes. A working paper by Hanushek, Piopiunik, and Wiederhold (NBER Working Paper No. 20727) uses a test of teacher cognitive skills as a variable for teacher quality, and then instrument it with the level of non-education public sector wages. While Hanushek, et al. were forced to estimate student-teacher relations due to not having direct student-teacher relationship data, their result shows a very important reevaluation of how responsive teacher quality is to labor market conditions. They noted that the countries with the highest level of teacher ability and student results were those who raised relative teacher salaries to a point where they were recruiting from the top echelon of graduating college classes. This is a result that reinforces my narrative: higher paid teachers lead to higher quality teachers, lead to better student outcomes.

²⁰Lateral entry allows individuals to obtain a teaching position and begin teaching right away, while obtaining a professional educator's license as they teach as long as they have a bachelor's degree.

Floridans can qualify for a temporary certificate with a Bachelor's Degree and a passing score on the Florida Subject Area Examination, and North Carolinians can do the same if they pass the Praxis exam or equivalent certification exam.

As shown by Lott, and Kenny (2013), the strength of teacher's unions can have significant effects on test scores. They can also affect teacher retention and ease of new hires. North Carolina and Florida systemically differ in their treatment of teacher's unions, with North Carolina having stronger union rights. According to Winkler, Scull and Zeehandelaar's (2012) ranking of overall teacher union strength, Florida is ranked 50th of the U.S. States and D.C, and North Carolina is ranked 40th. In terms of membership and resources they are tied at 47th. For bargaining status (mandatory, permitted, or prohibited), scope of bargaining, right of unions to deduct agency fees from nonmembers, and legality of teacher strikes, Florida is ranked 35th and North Carolina is ranked 48th. Regarding the union's involvement in politics (Teacher unions' share of financial contributions to state candidates and political parties, and their representation at the Republican and Democratic national conventions), Florida is ranked 36th and North Carolina is ranked 29th. As North Carolina's union is stronger than Florida's, I would expect the impact of labor market conditions on teacher displacement to be less.

18.2. Data

I was able to obtain standardized end of grade test scores from 3rd, 4th, 5th and 8th graders from 1995 to 2011. End of course standardized Algebra I and Algebra II test scores were included from 1999-2011. I was then able to match these scores to a variety of student characteristics using unique student identifier codes, as well as to their 5th grade and

Algebra II teachers.

For each year and grade I normalized the test scores. I coded a variety of dummy control variables. Ethnicity includes White, East Asian, Black, non white Hispanic, Indian and Mixed. Learning disabled took a value of 1 if the student was flagged as learning disabled in one or more of reading, math, writing, other, oral, fluency, computational skills, calculation skills or listening. Limited English took a value of one if the student had a positive L.E.P. status. A lunch assistance dummy had a value of one if the student was on free or reduced lunch.

Student test scores are the state end of grade standardized math tests in grades 3, 4, 5 and 8 as well as end of course standardized test scores for Algebra I and II, normalized by grade and year to have a mean of zero and standard deviation of one. The dependent variables are the grade 5 and Algebra II scores. My student characteristic controls are dummies for gender, ethnicity, free/reduced lunch, learning disability and limited English proficiency. The school control variables were the proportion in each school of different ethnicities and free/reduced lunch students. Grade by year fixed effects are also included. Nagler, et al. also include classroom level controls, which my data does not include.

Table 5 contains summary statistics on the races, genders, disabilities, limited english and free lunch for the 5th graders and Algebra II students that I have data on. Algebra students are relatively white with fewer learning disability students than the 5th grade standardized test takers.

The test lag coefficient is constrained using the technique of Jackson and Bruegmann (2009). Quoting them, "there is attenuation bias on the coefficient of lagged test scores, due to measurement error in test scores. If lagged test scores are correlated with other

covariates (very likely), this will bias the coefficients for all covariates.” I ran a 2sls IV regression, using 3rd grade math scores as an instrument for 4th grade math scores and 8th grade math scores as an instrument for Algebra I scores. The coefficient this generated was then used as the lag variable coefficient in my value added generating regression. The 4th grade coefficient ($\beta_1 = .971545$) is almost identical to Jackson and Bruegmann (0.97), which is as expected, as they used the exact same data set in their paper, albeit for an shorter span of years. The coefficient estimated using this IV regression is higher than it otherwise would have been (0.971545 versus 0.8027556 for 4th grade and 1.060309 versus 0.7997208 for Algebra I)

18.3. Empirical Methods

I run the following regression:

$$MathScore_{igst} = \beta_0 + \theta_j + \beta_1 MathScore_{igs(t-1)} + \beta_2 StudentCon_i + \beta_3 SchoolCon_{st} + \beta_4 GradebyYearFE_{tg} + \mu_{itgs}$$

for student i , teacher j , school s , year t and grade g .

θ is a teacher fixed effect and will generate the value added for the teacher used in the next section. This regression includes a set of demographic controls for the students and schools. Due to the fact that this inquiry requires its estimates of teacher value-added to be comparable across schools, I do not include school fixed effects. Something worth noting is that the teacher code attached to the student test score in this data is not always the teacher that taught the class, it is the teacher that administered the test. So if the original teacher was sick, or busy, or any other reason for being absent on the day of the exam,

a different teacher will get the credit (or the blame) for the students test scores. If either good or poor teachers consistently missed their test day (perhaps poor teachers are lazier, or good teachers have more important things to do) this could cause bias in the results. However, the NCEDRC estimates that the correct teacher is recorded over 95 percent of the time, and barring any convincing arguments for bias, it is safe to assume that this small flaw in the linkage will only result in additional noise in the data, rather than a false signal.

To look at the effect of the job market on the quality of teachers, I used a fixed effects regression.

$$TeacherValueAdded_j = \beta_0 + \beta_1 RecessionDummy_{jt} + \beta_2 TeacherControls_j + \mu_j$$

The variable of interest is a dummy variable that is 1 when a teacher is hired during a recession and 0 otherwise.

Teacher controls include gender, ethnicity, masters degree, and 30 years of experience dummies (Papay and Kraft, forthcoming). This again matches West, et al. Hire year was established by using the most recent record of the teachers level of experience and matching it to their most recent test, then taking the previous year to the first test date which is when the profession switch would be made, or two years previous to the test date in the case of Algebra II, to account for the greater difficulty in switching professions into high school relative to elementary school. Standard errors are then clustered by hire year. The data I use has 22,693 5th grade teachers, and 2924 Algebra II teachers. Summary statistics are reported in Table 7. Results are reported in Table 8. The two columns in the table are the

two regressions I ran for each group of teachers. I also run this regression only on teachers hired during a recession or 5 years previous to a recession, to match my labor sorting regressions and to ensure I am getting a clean comparison.

18.4. Results

I find that a recession in year of hire improves 5th grade test scores by 0.037 standard deviations and Algebra 2 scores by 0.07 standard deviations. The 5th grade coefficient is about half that estimated by West, et al. This may be a result of unseen attenuation bias from my imperfect teacher student matching, missing classroom level controls, or simply be a lower estimate in a range around the true parameter. The Algebra II coefficient is higher, but less significant, likely due to a smaller sample size. When I run the regression on the subsample of recessions plus 5 years previous, my coefficients strengthen slightly.

19. Falsification and Attrition

19.1. Falsification Tests

The main hypothesis advanced by this paper is that the teachers hired during recessions have a higher ability. In order to check whether this is a spurious result, I ran four regressions where the dummy variable indicated if the teacher had been hired up to four years before the recession. So the first regression has a dummy that is 1 when the teacher was hired one year after the recession. I ran regressions twice for each year, once for teacher's value added, and once for their certification test score.

$$TeacherValueAdded_j = \beta_0 + \beta_1 RecessionDummy_{j(t-n)} + \beta_2 TeacherControls_j + \mu_j$$

$$TeacherTestScore_j = \beta_0 + \beta_1 RecessionDummy_{j(t-n)} + \beta_2 TeacherControls_j + \mu_j$$

The variable of interest is a dummy variable that is 1 when a teacher is hired n years before a recession and 0 otherwise. The results are shown in Table 9. There was a total of 16 regressions ran, one for each combination of recession year - n dummy, grade and whether I was looking at the value added or certification scores for each teacher.

The lack of any significant trend in these results support that the effect generated by the recession year dummy did not happen by chance. There is a weak indication that teachers hired in the two years preceding a recession (when the economy is moving through the peak of the business cycle) are lower quality, which is consistent with the hypothesis of this paper, specifically a strong job market diverts good teachers away from the education occupation.

19.2. Differential Attrition

In this section I run two regressions that attempt to reveal any teacher attrition, that is, teacher's leaving the profession. This could be concerning if low skill teachers hired during a recession are more likely to leave the teaching profession than high skill teachers. If that is the case, my results could be driven by differential attrition rather than the recession

teachers having higher skills at time of hire.

The first regression reprises my earlier regressions, but instead of a dummy variable that is coded as 1 if the teacher was hired during a recession, it is coded as 1 if the teacher is hired during a specific year. If there is a clear trend that shows teachers hired during earlier recessions scoring significantly higher than teachers hired during more recent recessions, then there is cause for concern that the earlier recession also contained lower skill teachers that left the profession before they could be recorded. 1980-81 was combined due to lack of observations. A test year fixed effect was added to ensure I am comparing teachers who taught at the same time. Algebra II certification is omitted due to lack of observations on a year by year basis.

$$TeacherValueAdded_j = \beta_0 + \beta_1 SpecificRecessionDummy_{jt} + \beta_2 TeacherControls_j + TestYearFixedEffect_t + \mu_j$$

$$TeacherTestScore_j = \beta_0 + \beta_1 SpecificRecessionDummy_{jt} + \beta_2 TeacherControls_j + \mu_j$$

Results are shown in Table 10.

I find no clear downward trend in teacher value added (columns 1 and 2). In fact, I find some evidence of an upward trend in value added, indicating that high skill teachers leave the teaching profession at a higher rate than lower skill teachers. Again, this is consistent with the model of job market pressures. It seems that more severe recessions such as 1980-81 and 2007-08 have a much more severe impact on both value added and certification

than shorter duration recessions such as 1990 or 2001.

The second attrition test codes a dummy variable that attempts to capture teacher attrition directly. Specifically it is coded as 1 when there are no records for that teacher after 2009. I regress this on the value added, certification test scores and recession dummy as dependent variables, keeping the same teacher controls.

$$TeacherValueAdded_j = \beta_0 + \beta_1 AttritionDummy_{jt} + \beta_2 TeacherControls_j + \mu_j$$

$$TeacherTestScore_j = \beta_0 + \beta_1 AttritionDummy_{jt} + \beta_2 TeacherControls_j + \mu_j$$

$$RecessionDummy_j = \beta_0 + \beta_1 AttritionDummy_{jt} + \beta_2 TeacherControls_j + \mu_j$$

Results are in Table 11. There are a total of 8 regressions, 4 in the first row that regress the recession dummy on the attrition dummy for the two groups of teachers in each grade and 2 more for each grade, one for value added and one for the certification test.

Attrition does not have a significant effect on whether a teacher was hired during a recession, nor does it significantly impact value added or certification scores. I do not find attrition to be a significant factor in my findings.

19.3. Balancing Tests

Table 12 and 13 shows a regression of Individual, Student and School level observables on the treatment variable, which is recession after graduation or at time of hire. School controls are the proportion of that type of student in that school, which is only available for certain variables. For my ACS data I need to limit my sample to pass balancing tests, as the recession changed the observables of college graduates. Post recession college graduates had a higher proportion of females and non-whites. For the North Carolina data, I find no significant result of observables on my treatment variable, and my F scores are insignificant, ranging in probability from 0.44 to 0.58.

20. Conclusion

These results have important ramifications for policy makers. If the average quality of applicants increases during times of high unemployment, the hiring process would benefit from becoming counter-cyclical, hiring relatively more during times of economic distress. This would allow the education system to gain higher quality teachers, likely at lower cost, as well as functioning as a counter recessionary measure. Indeed, as the public education system is a non-trivial percentage of the GDP of the United States, a policy change that encouraged recessionary hiring could have a significant impact on alleviating and shortening recessionary periods.

This paper also shows the response of college students and graduates to labor market conditions. When teaching is seen as relatively more favorable, there is an increase in teacher quality. Increasing beginning teacher salaries to a point where the teaching profession attracts the top graduates will make it a more prestigious career choice and create

a virtuous cycle.

The success of Japanese and Nordic education models cannot be solely attributable to cultural differences, but also to the fact that the relative pay of teachers is so much higher. Emulating the countries emphasized by Hanushek, Piopiunik, and Wiederhold, and recruiting from the top echelons of college graduates, as well as paying a salary compatible with attracting such a elite group, will have a large effect on the outcomes for American students. Higher quality teachers have a large effect on their student outcomes, and policymakers should prioritize additional funding to raise teacher salaries.

Table 19: ACS Summary Statistics

	Non-Edu Degree	Edu Degree	All
Number of Individuals	334,691	30,829	2,019,486
Percentages			
Male	43.84	18.73	51.18
White	76.70	89.31	71.57
Black	6.51	4.45	12.15
Asian	11.58	2.87	4.8
Labor Force	86.27	90.55	72.71

21. Appendix

Notes: This table is made up of summary statistics for my ACS data, used to run the regressions contained in tables 2-3. The first panel is the number of individuals in each group. The second panel is the percentage of control attributes within each group. The first column is individuals with a bachelor's degree in an non-education related field, the second column is individuals with a bachelor's degree in a education related field. Asian is defined as individuals who responded Chinese, Japanese or Other Asian.

Table 20: Education Occupation Regression

Entire Sample		
Recession at Age	Edudegree	NonEdudegree
19-21	.00067835 (.0010924)	-.00010451 (.00022899)
22-24	.00133434 (.00112629)	.000963*** (.00027786)
Pre Recession Sub-Sample		
19-21	-.00072147 (.00138955)	-.0003116 (.0002545)
22-24	-.0002311 (.00121275)	.00064314** (.00025069)

Notes: This table is created from regressing a recession dummy that takes a value of 1 when an individual experiences a recession at a certain age on whether they are employed in the education occupation when asked to respond to the ACS. The columns show differing effects depending on whether the individual has a education or non-education related degree, This also functions as a falsification test similar to table 13. The first panel is my entire sample, which fails balancing tests, and the second is a subsample that excludes post-recession observations that passes balancing tests.

Table 21: Teacher Certification Score Summary Statistics

	Grade 5		Algebra II	
	Recession	Non-Recession	Recession	Non-Recession
Number of Teachers	782	2,918	74	367
Percentages				
Male	9.72	11.00	36.49	32.15
Asian	0.38	0.38	0	1.63
Black	11.51	13.88	14.83	16.35
Hispanic	0.38	0.31	0	1.09
Indian	0.90	1.17	0	.27
Mixed	0.38	0.31	1.35	0

Notes: The first panel is the number of teachers in each group. The second panel is the percentages of each control attribute in that group. These are the teachers who I was able to match to the Praxis PPST. They are all included in the larger group of teachers that are used for the value added regression, see table 10.

Table 22: Teacher Math Score regression

	5th Grade	Algebra II
Hired in recession	.10739791* (.05371536)	.11468167** (.05125446)
Ethnic controls	YES	YES
Gender controls	YES	YES
Subsample	.0531297* (.0297731)	.1123249* (.0647693)
Ethnic controls	YES	YES
Gender controls	YES	YES

Notes: The independent variable of interest is the recession dummy, the dependent variable is the certification score obtained. The first panel is my entire sample and the second is a subsample that excludes post-recession observations in order to match my labor sorting regression. Both samples pass balancing tests.

Table 23: Student Summary Statistics

	Grade 5	Algebra II
Total Number of Students	3,183,773	582,454
Percentages		
Male	50.96	45.88
Asian	2.02	2.52
Black	28.5	24.61
Hispanic	7.27	4.24
Indian	1.49	1.07
Mixed	2.47	1.80
Learning Disability	6.63	1.65
Limited English	1.08	1.68
Free/Reduced Lunch	23.3	29.57

Notes: The first panel is the number of students in each group. The second panel is the percentages of each control attribute in that group.

Table 24: N.C. and Florida Comparison

	North Carolina	Florida
Mean Elementary Salary	43,200	49,820
Mean Secondary Salary	44,730	52,640
Teacher Salary vs. State Average	1.28	1.23
Vacation Weeks per Year	15	15
Pupil/Teacher Ratio	14.12	14.33
Expenditure per Pupil	9,088	11,819

Notes; This table compares key statistics between North Carolina, my source of data, and Florida, where West, et al. sources their data.

Table 25: Teacher Value Added Summary Statistics

	Grade 5		Algebra II	
	Recession	Non-Recession	Recession	Non-Recession
Number of Teachers	3,942	18,751	575	2,349
Percentages				
Male	10.88	10.23	35.48	35.04
Asian	.30	.28	.70	1.61
Black	13.62	14.08	10.78	14.18
Hispanic	.60	.45	1.04	.72
Indian	.68	.89	1.04	.47
Mixed	.22	.19	.35	.26
Masters Degree	22.89	23.44	32.65	34.03

Notes: The first panel is the number of teachers in each group. The second panel is the percentages of each control attribute in that group.

Table 26: Teacher Value Added regression

	5th Grade	Algebra II
Hired in recession	.0373917*** (.0122074)	.0705392* (.0390345)
Experience Dummy	YES	YES
Ethnic controls	YES	YES
Gender controls	YES	YES
Subsample	.0458194*** (.0148793)	.1096588** (.049731)
Experience Dummy	YES	YES
Ethnic controls	YES	YES
Gender controls	YES	YES

Notes: The independent variable of interest is the recession dummy, the dependent variable is the teacher's value added. The first panel is my entire sample and the second is a subsample that excludes post-recession observations in order to match my labor sorting regression. Both samples pass balancing tests.

Table 27: Falsification Test

	Value Added		Certification Score	
	5th Grade	Algebra II	5th Grade	Algebra II
Recession-1	-.0476634 (.10972009)	-.0630376 (.0693325)	-.04573648 (.10877057)	-.08558957 (.05109763)
Recession-2	-.04443858 (.04614624)	-.0078595 (.084638)	-.07636872 (.04671956)	-.03061457 (.0447887)
Recession-3	.03918466 (.05717472)	.065524 (.0586436)	.06768578 (.05798671)	-.17954778 (.03036966)
Recession-4	.07512292 (.06424916)	-.067671 (.0663962)	.0685745 (.06351492)	-.02235235 (.0548125)

Notes: The 4 rows are years preceding a recession. The columns are different groups of teachers and different dependent variables.

Table 28: Attrition 1

	Value Added		Certification Score
	5th Grade	Algebra II	5th Grade
1980-81	.02695301*** (.01012379)	.15500636 (.13638222)	
1990	.01213874 (.01468411)	-.0415668 (.12876576)	
2001	.01000397 (.01318996)	-.06083326 (.05961745)	-.0518645 (.0345013)
2007	.07830627*** (.01960964)	.02394479 (.08020938)	.1478395*** (.0348863)
2008	.08235301*** (.03550584)	.24133456*** (.11245701)	.1302555*** (.0357959)

Notes: There was not enough 5th grade certification scores in my data set to do an attrition test for the recessions in 1980 and 1990.

Table 29: Attrition 2

	Value Added		Certification Score	
	5th Grade	Algebra II	5th Grade	Algebra II
Recession	-.08590634 (.06368004)	-.08199557 (.07176308)	-.08039573 (.0841072)	-.15305409 (.15173938)
Value Added	.01777684 (.01249187)	.04515967 (.03650339)		
Certification Test Score			-.06149843 (.04079742)	.04892467 (.08644482)

Notes: The first panel is a regression of the attrition variable on the recession dummy variable for each group of teachers. The second panel is a regression of the attrition variable on the Certification Score variable for each group of teachers. The third panel is a regression of the attrition variable on the Value Added variable for each group of teachers. Remember that the certification score teachers are a subset of my value added teachers. See tables 9 and 10.

Table 30: Balancing Test

Entire Sample	
Black	-.0085195** (.0029208)
Hispanic	-.0152657* (.0055015)
Female	-.005848** (.0017987)
Sub-Sample	
Black	-.0042449 (.003082)
Hispanic	-.005377 (.0058161)
Female	-.0027925 (.0022543)

Notes: This is a regression of individual level observables on the treatment variable for my labor market sorting regression. The first panel is my entire sample, which fails, and the second excludes post recession variables, which passes.

Table 31: Balancing Test

	Student Control	School Control
F score	0.87	0.95
Prob > F	0.5843	0.4414
Black	.0202727 (.010194)	-.0176336 (.0682675)
Hispanic	.0188191 (.0311497)	.0053445 (.0540049)
White	.0119048 (.01217)	-.032867 (.0508018)
Male	-.0001716 (.0007364)	
Learning Disabled	.0007825 (.00486)	
Limited English	.0144246 (.0453632)	
Reduced Lunch	-.0009783 (.0226035)	-.0195115 (.0268331)

Notes: This is a regression of Student and School level observables on the treatment variable. School controls are the proportion of that type of student in that school, which is only available for certain variables.

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