

War Debt and the Baby Boom

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Abstract

I propose a novel explanation of the postwar baby boom in the U.S. I argue that the dramatic drop in the government debt-GDP ratio after WWII was an important cause of the baby boom. The debt-GDP ratio peaked at 108% in 1946, and it dropped dramatically in the following two decades. The ratio was only 28% in 1970. Simultaneously, the U.S. experienced a massive baby boom. I propose a causal link between these two phenomena. My theory emphasizes two mechanisms. First, a drop in the debt-GDP ratio affects fertility by changing the tax burden of different generations: it raises the current income tax rate and implies lower tax burden on children in the future. A higher current income tax rate raises fertility by lowering after-tax wage and therefore the opportunity cost of child-rearing (when the cost of child-rearing involves parental time). A lower tax burden on children in the future raises the children's lifetime utility, which also raises current fertility if parents have Barro-Becker type preferences (the children's utility is included in the parents' utility function). The second mechanism works via the capital-labor ratio. Government debt (internal debt) has crowding out effect on aggregate capital (see Diamond (1965)). Therefore, a drop in the debt-GDP ratio boosts the aggregate capital level and raises the capital-labor ratio, which in turn implies higher wage rates and lower interest rates in the future. Lower interest rates raise fertility by inducing parents to substitute their old-age savings for children. Higher wage rates raise children's utility, thus raising fertility. These two mechanisms worked together and contributed to the postwar baby boom in the U.S.. My theory is also consistent with an interesting cross-sectional property of the baby boom: the size of the baby boom was much larger among richer households. Given the progressivity of the income tax system, richer households share a proportionally larger part of the tax burden. Therefore, the first mechanism described above should have larger effects for richer households, generating a comparatively larger baby boom among them. The quantitative exercise shows that the model can explain 47% of the baby boom, and it also matches the cross-sectional properties of the baby boom well.

Keywords: Baby boom, Government debt, WWII.

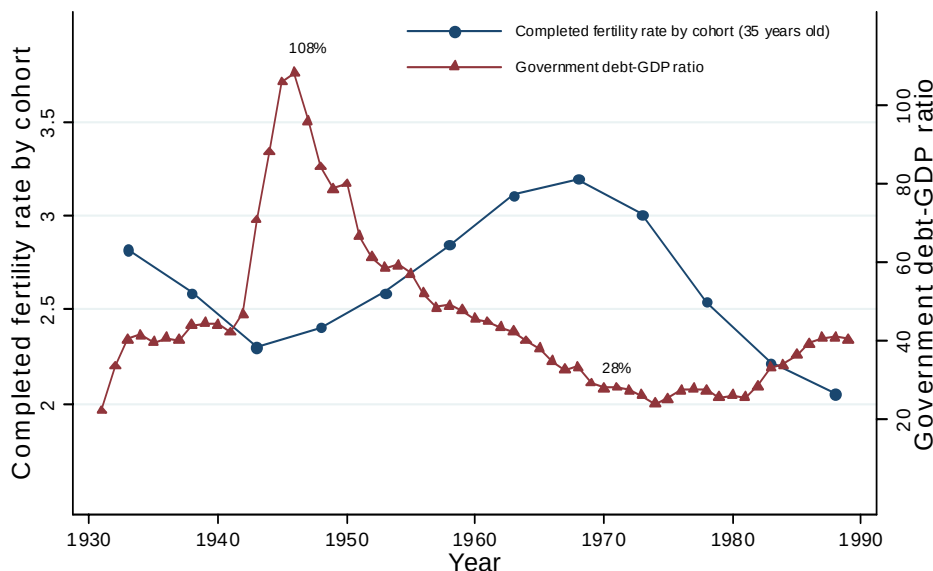
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1 Introduction

The United States experienced a massive baby boom during the two decades following the Second World War. As documented by Jones and Tertilt (2007), the completed fertility rate was 2.4 for the cohort of women born in 1911-1915 (who completed most of their fertility by the 1940s), and increased to 3.2 for the cohort of women born in 1931-1935 (who completed most of their fertility by the 1960s).¹ Simultaneously, the government debt-GDP ratio dropped dramatically, from 108% in 1946 to 28% in 1970. Both patterns are demonstrated in Figure 1.

Figure 1: The debt-GDP ratio and cohort fertility in the U.S..



(Data source: 1. debt-GDP ratio: OMB/Budget of the U.S. Government (since 1940), derived by the author from the data provided by U.S. Bureau of the Census and <http://www.measuringworth.org> (before 1940); 2. cohort fertility: Jones and Tertilt (2007).)

What impact could government debt have on fertility? Is there a role for government debt in accounting for the postwar baby boom in the U.S.? I answer these questions in this paper. I

¹A similar pattern is observed in the data on total fertility rate. The total fertility rate was 2.5 in 1945, and it rose to 3.8 in 1957 (see figure 14). In this paper, I focus on the baby boom measured by cohort fertility since this measurement better matches the fertility definition in my model.

argue that the dramatic drop in the debt-GDP ratio had a positive effect on fertility and was an important factor causing the postwar U.S. baby boom. Two mechanisms are at work here. First, government debt affects fertility by changing the tax burden of different generations: a reduction in the debt-GDP ratio raises the current income tax rate and implies a lower tax burden on children in the future.² A higher current income tax rate raises fertility by lowering after-tax wage and therefore the opportunity cost of child-rearing (when the cost of child-rearing involves parental time). A lower tax burden on children in the future raises the children's lifetime utility, which also raises the current fertility if parents have Barro-Becker type preferences (the children's utility is included in the parents' utility function).

The second mechanism works via the capital-labor ratio. Government debt (internal debt) has crowding out effect on aggregate capital (see Diamond (1965)). Therefore, the drop of the debt-GDP ratio boosts the aggregate capital level and raises the capital-labor ratio, which in turn implies higher wage rates and lower interest rates in the next period through general equilibrium effects. Lower interest rates raise fertility by inducing parents to substitute their old-age savings for children. Higher wages raise children's utility, thus they also raise fertility in the same way as a lower future tax burden. These two mechanisms worked together and contributed to the postwar baby boom in the U.S.

To formalize the argument, I develop an overlapping-generation model with endogenous fertility and heterogeneous agents. In my model, there are three periods: childhood, middle age, and old age. Only the middle-age agents are endowed with one unit of time which can be used to rear children or work. The middle-age agents have Barro-Becker type altruism toward their children (the children's utility is included in the parents' utility function)(Barro and Becker (1988), Becker and Barro (1989)). After they receives an ability shock at the beginning of the middle age, the

²Note that I do not mean that the reduction in the debt-GDP ratio is only caused by an increase in current income tax rate. It may also be due to economic growth. In fact, around half of the reduction in the debt-GDP ratio during the two decades following WWII is from economic growth. In my quantitative exercise, I model this effect of economic growth on the debt-GDP ratio seriously.

agents maximize their lifetime utility by choosing fertility, middle-age consumption, and old-age savings. In the benchmark model, the children and old-age agents make no economic decisions. For simplicity, I also assume that the parents have no ability to change their children's utility (through bequest or human capital investment). Government debt exists in the economy, and the debt-GDP ratio is constant in the stationary equilibrium. A standard Cobb-Douglas production technology is assumed on the production side. I calibrate the model such that the initial stationary equilibrium matches some moments of the U.S. economy prior to the baby boom. I then shock the stationary equilibrium by temporarily raising the labor income tax rate to pay back a part of the existing debt and drive down the debt-GDP ratio to the post-baby boom level.³ I compare the transition path with the postwar baby boom in the U.S.

I find that the transition path generated by the policy shock mimics the baby boom. The fertility rate jumps immediately when the policy shock hits, and then drops in the following period, as in the baby boom in the U.S. during the two decades after WWII and the baby bust directly following it. Quantitatively, the magnitude of the baby boom generated in my model accounts for 47% of that observed in the data.

An important assumption in my theory is that the government imposed higher income tax rates on people after WWII to drive down the debt-GDP ratio.⁴ Is it true that the U.S. government taxed people heavily after the war in order to drive down the debt level? Some supporting evidence can be found in the following letter written by President Truman to the House of Representatives:

“... My fundamental objection to the bill is that it would not strengthen, but instead would weaken, the United States.

This is true for two reasons.

³Note that a higher labor income tax rate is not the only reason that the debt-GDP ratio goes down. The GDP growth also drives down the debt-GDP ratio even the tax rates are constant. In the quantitative exercise, I also take into account the effect of growth on the debt-GDP ratio by modeling technological progress seriously.

⁴Note that here I mean the postwar income tax rates are higher compared to the prewar tax rates. The income tax rates during the war could be extremely high for other reasons (paying for the direct cost of the war, etc.).

First, the bill would reduce Government revenues to such an extent as to make likely a deficit in Government finances, at a time when responsible conduct of the financial affairs of this Nation requires a substantial surplus in order to reduce our large public debt and to be reasonably prepared against contingencies. ...”

—————President Harry S. Truman, April 1, 1948
<<*Truman’s Veto of the Income Tax Reduction Bill*>>

From this letter, it is clearly seen that President Truman insisted on debt reduction over tax cuts when the war was over. This reflects that the postwar U.S. government did want to drive down the debt level by keeping the income tax rates at relatively high levels. Figure 2 plots the U.S. federal income tax rates (top and bottom income brackets).⁵ As can be seen, after WWII the income tax rates did not go back to the prewar levels, instead they remained high for the following two decades. Especially, the top bracket rate, which was below 30% in 1930, jumped above 90% at the end of WWII and remained at around 90% throughout the whole baby boom period. The bottom tax rate also demonstrated a similar pattern.

Another important implication of my theory is that the income tax rates should go down after the baby boom. We can see in figure 2 that after the 1960s the top rate started to fall and it went down to around 30% again by the 1990s. Similar pattern is observed on the bottom tax rate. Figure 3 plots the effective income tax rate for the median income family in the U.S. It was below 5% before 1940. It jumped above 20% during WWII and kept above 20% afterwards. Then, it experienced a significant drop in the middle of the 1960s and another big drop at the beginning of the 1970s. Since then, the effective income tax rate is around 15% for the median income family. Figure 3 says that the median income family in the U.S. faces a significantly lower tax burden after the baby boom than before. Note that, the welfare state has expanded dramatically in the last several decades (see Figure 4). Therefore, if I only consider the tax rates attributed to the financing

⁵Since the realistic income tax system is fairly complicated, and involves many income brackets and the number of income brackets varies over time, I only present the tax rates for the first income bracket and the top income bracket.

of government debt, the drop in income tax rates should be even larger after the baby boom.

An interesting cross-sectional property of the baby boom is that: the size of the baby boom was much larger among richer households. As documented in Jones and Tertilt (2007), the size of the baby boom was much larger among richer households (see Figure 5(a)). The size of the baby boom was 0.79 children for the whole population. However, the women in the bottom half of the income distribution only had a baby boom of 0.7 children, while the women in the top half of the income distribution had 0.88 more children during the baby boom. This property would be even more evident if the size of the baby boom is measured by percentage change (see Figure 5(b)).⁶ This is due to the fact that the fertility of the rich was much lower than the poor before the baby boom. I argue that my theory can also account for the cross-sectional feature of the Baby Boom. The mechanism is as follows. Since income taxation was progressive in the U.S., richer households shared a proportionally larger part of the tax burden. Thus, the first mechanism described above should have larger effects for richer households, generating a comparatively larger baby boom among them. The quantitative exercise shows that the model also does an good job of producing this cross-sectional property of the baby boom.

Recently, there has been a growing literature that tries to account for the baby boom using quantitative macro models.⁷ Several interesting explanations of the baby boom have been proposed. Greenwood, Seshadri, and Vandenbroucke (2005) argue that the baby boom was due to a positive shock in home production technology. Here the positive shock refers to the widespread diffusion of electrical appliances such as refrigerators, laundry machines, and dishwashers during the baby boom period. These appliances freed women from housework and lowered the opportunity cost of child-rearing. The Greenwood et al. model can produce a baby boom comparable to the one observed in the data, but it fails to produce an immediate baby bust following the baby boom.

⁶As demonstrated in Figure 5(b), while completed fertility rate increased by 33% for the whole population, it only increased by 27% for the poor, and by 40% for the rich.

⁷Greenwood, Seshadri, and Vandenbroucke (2005), Doepke, Hazan, and Maoz (2007), Simon and Tamura (2007), etc.

Another important explanation is from Doepke, Hazan, and Maos (2007). They argue that WWII produced a large number of women with work experience. Assuming that the market rewards work experience, women with work experience would tend to remain in the labor force after the war, making the labor market more competitive for young women with little work experience. Therefore, these young women would be more likely to get married earlier and have more children. An important piece of empirical evidence supporting their story is that the baby boom was mainly generated by young women. Their theory is complementary to my theory. Both emphasize the role of WWII in generating the baby boom, and both argue that the low opportunity cost of child-rearing was one of the forces driving the baby boom. The difference is that Doepke et al. (2007) focus on how a more competitive labor market reduces the cost of child-rearing. In contrast, my theory focuses on how government taxation reduces the after-tax wage and the cost of child-rearing. My theory also points out that the drop in the government debt-GDP ratio changes the parents' expectations about their children's utility in the future, another possible force driving the baby boom. Furthermore, my theory captures the general equilibrium effects on fertility from the change in the capital-labor ratio caused by the dramatic drop of the debt-GDP ratio after WWII.

This paper is also related to Wildasin (1990), and Lapan and Enders (1990). Both papers study the role of government debt in a model with endogenous fertility, and demonstrate theoretically that a decrease in government debt can bolster fertility. However, they do not further quantify the effect of government debt on fertility, and they also do not relate their theories to the baby boom. To the best of my knowledge, this paper is the first to quantitatively investigate the effects of government debt on fertility and its explanatory power for the postwar baby boom in the U.S.

2 Other Countries and Other Periods

The baby boom phenomenon was not unique to the United States. Most industrialized countries also experienced a baby boom roughly around the same period. Is international evidence consistent with my theory? One implication of my theory is that countries that experienced a larger reduction

in the debt-GDP ratio should have had a larger baby boom. Here I investigate whether this implication holds true in the data.

Following Doepke, Hazan, and Maoz (2007), I divide the industrialized countries into three groups: 1) allied countries that did not fight on their own soil, 2) neutral countries, 3) countries that fought on their own soil. I argue that besides the government debt problem, the third group of countries also needed to deal with postwar reconstruction, which has similar effects on fertility as government debt, according to my theory. This reconstruction problem may distort the true correlation between government debt and fertility among these countries; thus, I only look at the first two groups of countries. Figure 6 plots the time series of the debt-GDP ratio for the first group of countries (the United States, Canada, Australia, and New Zealand). Figure 7 plots the time series of the debt-GDP ratio for the second group of countries (Sweden, Spain, Switzerland, and Portugal). All in the first group experienced a large reduction in the debt-GDP ratio after the war, while all in the second group did not. My theory predicts that the first group should have a larger baby boom than the second group. Two graphs from Doepke, Hazan, and Maoz (2007) plot the time series of completed fertility rate by cohort for both groups of countries (see Figures 8 and 9). I find that the first group of countries had a much larger baby boom than the second group. However, as argued by Doepke, Hazan, and Maoz (2007), the difference between the first group and the second group may be also because of the fact that the first group generated a large number of experienced female labor during the war, while the second group did not. In other words, though the international evidence is consistent with my theory, it does not distinguish my theory from the Doepke et al. model.

It is also interesting to examine whether the correlation between government debt and fertility holds true in other time periods. Figure 10 plots the federal government debt-GDP ratio in the U.S. since 1849. I can see that the other two significant reductions in the debt-GDP ratio happened after the 1860s (civil war) and the 1910s (WWI), respectively. Using the HP filter to detrend the U.S. time series of completed fertility rate, I find that fertility positively deviated from the trend in

both time periods (see figure 10). This suggests that my theory also holds in other time periods.⁸ Figure 10 also provides evidence distinguishing my theory from the Doepke et al model. Since the female labor participation rate was very low before the 1920s, the Doepke et al. theory should not be an important factor responsible for the fertility variations after either the civil war or WWI. Caution needs to be taken when applying my theory to other time periods: if the variation in government debt is not caused by exogenous shocks (such as war), the effect of debt on fertility can be ambiguous because people's expectations on the government's behaviors in the future may be ambiguous. Furthermore, if the government debt is used to finance for public education or any other public programs that affect future generations, the effect of debt on fertility is also ambiguous.

3 The Model

Consider an economy inhabited by overlapping generations of agents who live for three periods: childhood, middle age, and old age. At the beginning of the middle age, the agent is hit by a productivity shock ϵ and endowed with one unit of time which can be used to work or rear children. The middle-aged agent chooses his fertility, middle-age consumption, and old-age saving. No decisions are made in childhood, and the old-age agent only consumes what he saves from the middle age. For simplicity, we assume the parent does not have the ability to change the children's utility in the benchmark model (through bequest or human capital investment).⁹

Assume that the agent has Barro-Becker type preferences (the children's utility is included in his utility function). The following is the lifetime utility function of the agent with ϵ .

$$u(c_m) + \beta u(c'_o) + \beta \gamma n^\theta E[V'(\epsilon') \mid \epsilon] \quad (1)$$

⁸Note that I do not mean to explain all the fertility variations happened after the civil war and WWI by the changes in the debt-GDP ratio, since some other elements may also affect fertility, i.e. mortality and economic growth.

⁹I extend the model to include intergenerational transfers in the appendix.

with

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma}. \quad (2)$$

The first term represents the utility from middle-age consumption which is denoted by c_m . The second term represents the utility from old-age consumption c'_o . The third term represents the parent's altruism toward his children. Note that n is the number of children, $V'(\cdot)$ is the value function of children, and ϵ' is the children's productivity which is unknown to the middle-age parent. Note that γ is the weight on altruism, and θ is the curvature on the number of children. The agent faces the following budget constraints:

$$s + c_m = (1 - \tau)\epsilon w(1 - bn), \quad (3)$$

$$c'_o = (1 + r')s, \quad (4)$$

where b is the time cost of child-rearing, τ is the labor income tax,¹⁰ and s is the saving for old age. The wage and interest rate are represented by w and r' respectively.

The middle-age agent's problem (P1) can be written as a Bellman equation,

$$V(\epsilon) = \max_{n,s} u(c_m) + \beta u(c'_o) + \beta \gamma n^\theta E[V'(\epsilon') \mid \epsilon] \quad (5)$$

s.t.

$$s + c_m = (1 - \tau)\epsilon w(1 - bn),$$

$$c'_o = (1 + r')s,$$

On the production side, a standard Cobb-Douglas production technology is assumed. Production is undertaken in a firm in accordance with

$$Y = K^\alpha (AL)^{1-\alpha}. \quad (6)$$

¹⁰To make income tax progressive, we assume τ increases with ϵ in our benchmark calibration. However, the progressivity of income tax is randomly picked for now. I would like to match the progressivity observed in the data in the next draft.

Let $\alpha \in (0, 1)$, and let capital depreciate at a rate of δ . The firm chooses capital K and labor L by maximizing profits $Y - wL - (Y_k - \delta)K$. The labor-augmented technology A is assumed to grow at a rate of g .

The productivity shock $\epsilon \in \{\epsilon_1, \epsilon_2, \dots, \epsilon_m\}$, is governed by a Markov chain with transition matrix $\pi(i, j) = \text{Prob}(\epsilon' = \epsilon_j | \epsilon = \epsilon_i)$. The Markov chain is approximated from the log-normal AR(1) process

$$\ln \epsilon' = \rho \ln \epsilon + u', u' \sim N(0, \sigma_u^2), \quad (7)$$

where ρ is the intergenerational persistence coefficient.

Denote the distribution of the middle-age generation by the density function $\Phi(\epsilon)$. I have the following market clearing conditions:

$$K = \frac{N_{-1}}{N} \sum_{i=1}^m \Phi_{-1}(\epsilon_i) f_{-1}^s(\epsilon_i), \quad (8)$$

and

$$L = \sum_{i=1}^m \Phi(\epsilon_i) \epsilon_i (1 - b f^n(\epsilon_i)). \quad (9)$$

Here $f^s(\cdot)$ and $f^n(\cdot)$ represent the agent's decision rules for saving and fertility. The law of motion for the population measure of each generation, N , is as follows:

$$N' = N \sum_{i=1}^m \Phi(\epsilon_i) f^n(\epsilon_i), \quad (10)$$

and the law of motion for the density function $\Phi(\epsilon)$ is,

$$\Phi'(\epsilon_j) = \frac{N}{N'} \sum_{i=1}^m \Phi(\epsilon_i) f^n(\epsilon_i) \pi(i, j), \forall j \in \{1, 2, \dots, m\}. \quad (11)$$

I assume that there exists government debt in the economy, which is denoted by B (per middle-

age person). The government's budget constraint (per middle-age person) can be written as follows,

$$(1 + r)B = \frac{NB'}{N'} + w \sum_{i=1}^m \Phi(\epsilon_i) \epsilon_i (1 - b f^n(\epsilon_i)) \tau. \quad (12)$$

I assume that the government's debt policy at the stationary equilibrium is to keep the government debt-GDP ratio constant, and labor income tax is the only tax tool available to the government.¹¹ It is easy to see that this policy implies that the amount of government debt per middle-age person is also constant in the stationary equilibrium, $(1 + g)B = B'$. The government's budget constraint (per middle-age person) becomes,

$$\left[1 + r - (1 + g) \frac{N}{N'} \right] B = w \sum_{i=1}^m \Phi(\epsilon_i) \epsilon_i (1 - b f^n(\epsilon_i)) \tau. \quad (13)$$

I can define the competitive equilibrium as follows.

Definition 1 *A **competitive equilibrium** consists of a set of prices (r, w) , a set of government policy parameters (τ, B) , laws of motion for K , L , N , and Φ , the agent's value functions $V(\cdot)$, and policy functions $f^n(\cdot)$, and $f^s(\cdot)$, such that:*

1. *given the prices and government policy parameters, the value function $V(\cdot)$ and the policy functions $\{f^n(\cdot), f^s(\cdot)\}$ solve the agent's problem (P1);*
2. *the firm's choices maximize its profits;*
3. *the prices w and r clear the markets, i.e. conditions (8) and (9) are satisfied;*
4. *the population of each generation, N , evolves according to (10) ; and the distribution evolves according to (11);*
5. *the government budget constraint (13) is satisfied.*

When the equilibrium is a stationary equilibrium, the following should be true: 1) r , $\frac{K}{AL}$, τ , Φ , and $f^n(\cdot)$ are constant; 2) B , w , and $f^s(\cdot)$ grow at the rate of g ; 3) L and N grow at a constant

¹¹I abstract from capital income tax in this paper for simplicity. However, it would be interesting to think about the effect of capital income tax on fertility. For example, capital income tax does not reduce the parents' child-rearing cost, but it may encourage the parents to substitute old-age savings for children. It is much more complicated to analyze its distributional effects, since they heavily depend on the wealth distribution in the economy.

rate that is equal to the population growth rate; 4) the value function $V(\cdot)$ evolves according to $V'(\cdot) = (1 + g)^{1-\sigma} V(\cdot)$.

Since the model cannot be solved analytically, I switch to analyze a simplified version of the model in next section to provide some intuition about how the model works.

4 Theoretical Analysis

Recall that government debt affects fertility via the income tax rates of different generations and prices. In this section, I derive some analytical results in a simplified version of the model to shed some lights on how exactly the income tax rates and prices affect fertility.

I simplify the model in two ways: 1) individual heterogeneity is assumed away, and agents are identical within each generation; and 2) the prices r_t and w_t are exogenously determined. In this simplified model, each middle-age agent in period t faces the following problem.

$$V_t = \max_{c,n} u(c_t^m) + \beta u(c_{t+1}^o) + \beta n_t^\theta V_{t+1} \quad (14)$$

s.t.

$$c_t^m + \frac{c_{t+1}^o}{1 + r_{t+1}} + n_t b w_t (1 - \tau_t) = w_t (1 - \tau_t), \quad (15)$$

where V_{t+1} is the utility function of a representative child. As is standard, $\theta \in (0, 1)$. Note that γ is assumed to be one here.

The following equation can be derived from the first order conditions (FOCs),

$$u'(c_t^m) b w_t (1 - \tau_t) = \beta \theta n_t^{\theta-1} V_{t+1}, \quad (16)$$

where $c_t^m = \frac{(1-\tau_t)w_t(1-n_t b)}{\beta^{1/\sigma}(1+r_{t+1})^{(1-\sigma)/\sigma} + 1}$.

Using $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, and after some algebra,

$$\frac{\left(\frac{\beta\theta V_{t+1}}{b}\right)^{1/\sigma} [w_t(1-\tau_t)]^{1-1/\sigma}}{\beta^{1/\sigma}(1+r_{t+1})^{(1-\sigma)/\sigma} + 1} = \frac{n_t^{(1-\theta)/\sigma}}{1-n_t b}. \quad (17)$$

Equation (17) states how the current fertility decision n_t is determined. It can be seen that n_t is a function of w_t , τ_t , r_{t+1} , and V_{t+1}

Proposition 1: *When $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, the following two statements are true:*

1. $\tau_i \downarrow \Rightarrow V_{t+1} \uparrow$, for any $i \geq t+1$.
2. $w_{t+1} \uparrow \Rightarrow V_{t+1} \uparrow$.

Proof: These two statements directly follow from the fact that $u'(c) > 0$.

Proposition 2: *Under the standard assumptions of the Barro-Becker model: 1) $0 < \theta < 1$; 2) $0 < \sigma < 1$, the following three statements are true:*

1. $\tau_t \uparrow \Rightarrow n_t \uparrow$
2. $r_{t+1} \downarrow \Rightarrow n_t \uparrow$
3. $V_{t+1} \uparrow \Rightarrow n_t \uparrow$.

Proof: All three statements can be derived from equation (17). The first statement follows from the fact that the left-hand side (LHS) of equation (17) is increasing in τ_t , and the RHS of equation (17) is increasing in n_t . The second statement follows from the fact that the LHS of equation (17) is decreasing in r_{t+1} , and the RHS of equation (17) is increasing in n_t . The third statement is from the fact that the LHS of equation is increasing in V_{t+1} , and the RHS of equation is increasing in n_t .

Proposition 1 and 2 together give us the following results:

Corollary 1: *Under the standard assumptions of the Barro-Becker model: 1) $0 < \theta < 1$; 2) $0 < \sigma < 1$, we have the following four results:*

1. $\tau_t \uparrow \Rightarrow n_t \uparrow$
2. $\tau_i \downarrow \Rightarrow n_t \uparrow$, for any $i \geq t+1$.

3. $w_{t+1} \uparrow \Rightarrow n_t \uparrow$.

4. $r_{t+1} \downarrow \Rightarrow n_t \uparrow$

Recall that government debt affects fertility via two mechanisms. The first two results correspond to the first mechanism: a reduction in the debt-GDP ratio raises the current period labor income tax rate and lowers future labor income tax rates. The last two results correspond to the second mechanism: the drop of the debt-GDP ratio (internal debt) leads to a jump in capital-labor ratio, which in turn raises w_{t+1} and lowers r_{t+1} .

5 The Benchmark Calibration

In the rest of the paper, I quantitatively investigate how the dramatic drop of the debt-GDP ratio after WWII affected fertility. My quantitative strategy is as follows. First, I calibrate the initial stationary equilibrium so that it mimics the U.S. economy right after WWII (in 1946), in which the government debt-GDP ratio was 108%. Then, I shock the stationary equilibrium by temporarily raising the labor income tax for one period to drive down the government debt-GDP ratio to the new target: 28% (which mimics the year of 1970). I compare the transition path generated in the model with the postwar baby boom in the U.S.¹²

Note that though I assume that the government temporarily raised income tax rates to drive down the debt-GDP ratio in the model, what really happened in the data is that the income tax rates were raised to an extremely high level during WWII, and after the war the U.S. government kept the high income tax rates for the following two decades to drive down the debt-GDP ratio instead of cutting the income tax rates to the prewar level immediately (see figure 2 and 3).

¹²An alternative strategy is to calibrate the initial stationary equilibrium to match the pre-WWII economy (in 1940), in which the debt-GDP ratio is 44%. Then, the economy is shocked by a war at the beginning of the period (before the production takes place), which drives up the debt-GDP ratio to 108%. The government raises the income tax rate to pay back part of the debt within the same period so that the debt-GDP ratio drops down to 28% in the next period. Then I compare the transition path with the postwar baby boom in the U.S. I find that with this alternative strategy, the results are only slightly different from the benchmark one. With this alternative strategy, the model explains 42% of the postwar baby boom in the U.S.

I first calibrate the model to match the key moments of the U.S. economy right after WWII. I assume that the length of a model period is 20 years, which roughly represents the time gap between two generations in the real economy. There are in total 10 model parameters (see table 1). The intergenerational persistence coefficient, ρ , is assumed to be between zero and one, which means that earning ability is mean-reverting over generations. This assumption is supported by a large amount of empirical evidence,¹³ and it gives us the result that in this model the poor tend to have more children than the rich, which is a well-observed fact in the fertility data.¹⁴ I set ρ to 0.667 based on the empirical estimation by Zimmermann (1992).

The altruism weight, γ , is chosen to match the completed fertility rate of the cohort born between 1911 and 1915, which is 2.4 (Jones and Tertilt, 2007). The standard deviation, σ_μ , directly affects the lifetime earnings inequality in the economy. Thus, we calibrate it to match the Gini coefficient of lifetime earnings in the U.S. economy after WWII (Friesen and Miller, 1983).

As is standard in the Barro-Becker model, the curvature on the number of children, θ , is assumed to be between zero and one, which means that the quality and the quantity of children are complements to each other in my model.¹⁵ Note that θ is a very important parameter in this model, since its value directly determines the size of the baby boom generated in our model. When θ is closer to one, the marginal utility of having an extra child would diminish more slowly, which makes the parent increase fertility after expecting an increase in the children's utility in the future. Thus, the model economy would respond with a larger baby boom to the debt policy shock. When θ is closer to 0, the opposite is true. To the best of my knowledge, there is no empirical estimate about θ in the existing literature. Since θ also affects the magnitude of differential fertility (by

¹³Solon (1992) and Zimmerman(1992).

¹⁴The reason why the poor tend to have more children in this model is as follows. Poor parents tend to have more children because they expect their children will have a relatively higher earnings ability than themselves and a higher utility. Furthermore, poor parents face a low opportunity cost of child-rearing because of the low price of their time. See Zhao (2009) for detailed explanation of the driving forces behind differential fertility. Jones, Schoonbroodt, and Tertilt (2008) provide a complete survey of the literature on differential fertility.

¹⁵Jones and Schoonbroodt (2009) propose an alternative hypothesis, in which they assume that θ is larger than one. Therefore, the quality and quantity of children are substitutes to each other. In their model, my mechanisms would run in the opposite direction.

income), I calibrate θ to match the actual magnitude of differential fertility by income among the cohort of women born between 1911-1915.¹⁶ The value of θ is set to 0.52. Following Doepke (2005), σ is set to 0.5. The time cost of child-rearing, b , is set to 0.075 according to Haveman and Wolfe (1995).¹⁷ For simplicity, I assume that the labor-augmented technology A grows at an annual rate of 1%, which roughly matches the rate of technological progress in the 20th century in the U.S. (see Greenwood, Seshadri, and Vandenbroucke (2005)). I choose the amount of government debt per middle-age person B so that the debt-GDP is 108% in the initial stationary equilibrium, which matches the data in 1946.

The remaining parameter are all standard thus values from the existing literature are used: I set the capital income share, α , to 0.3, the yearly capital depreciation rate to 0.12 ($\delta = 1 - (1 - 0.12)^{20}$), and the yearly time discount rate to 0.96 ($\beta = 0.96^{20}$). All the parameter values are summarized in table 1. This set of parameter values give us a (yearly) interest rate of 5% in the initial equilibrium and 4% in the post-baby boom equilibrium.

Table 1: Benchmark model calibration

Parameter	Interpretation	Value
g	the rate of technological progress	1% (annual)
α	Capital share	0.3
δ	Capital depreciation rate	0.12 (annual)
σ	Elasticity of substitution	0.5
β	Time discount factor	0.96 (annual)
σ_μ	Stand. dev. of the log of earnings ability	0.32
b	Time cost of children	0.075
ρ	Intergen. persistence of the earning ability	0.667
γ	Altruism weight	0.158
θ	Curvature of utility of children	0.52

¹⁶Here we use the income elasticity of fertility as the measurement of differential fertility by income. The income elasticity of fertility is -0.35 among the cohort of women born between 1911 and 1915.

¹⁷Haveman and Wolfe (1995) find that rearing a child takes about 15% of the parent's time. I assume that children live with the parent for 15 years and the parent's working career is 30 years. Thus, the time cost of rearing a child should be two thirds of Haveman and Wolfe's estimate, which is 0.075. de la Croix and Doepke (2003) use the same method to calibrate the time cost of child-rearing.

6 Quantitative results

For the quantitative exercise, I first compute the initial stationary equilibrium and the after-shock stationary equilibrium. Then, I compute the transition path between them. Figure 11 plots the fertility time series on the transition path. It can be seen that the model produces very good qualitative results. The fertility rate rises immediately in the period when the policy shock hits, which mimics the baby boom. Furthermore, the fertility rate drops quickly in the following period, mimicking the baby bust directly following the baby boom in the data. Table 2 reports some characteristics of the model economy on the transition path. It is clear that the labor income tax rate does increase dramatically in the period of policy shock. It jumps from 6.9% to 10.7% immediately and then drops to 1.1% in the following period. This pattern is also observed in the postwar data. However, the drop in the labor income tax rate after the baby boom is smaller in the data. This may be due to the fact that the size of the welfare state dramatically expanded after the 1960s, which drives the labor income rate in the opposite direction (see figure 4). It is worth mentioning that I do not mean to match the actual income tax rates in the data since part of the income taxes are attributed to the government services and welfare programs and the magnitude of these services and programs vary significantly over time.

Table 2 also lists the information on fertility by income.

Table 2: Characteristics on the transition path			
	Period 1	Period 2	Period 3
	(pre-the baby boom)	(hit by the policy shock)	
τ^1 (lowest income bracket)	6.9%	10.7%	1.1%
cohort fertility (all)	2.41	2.78	2.54
cohort fertility (poor half)	2.67	2.99	2.84
cohort fertility (rich half)	2.15	2.58	2.26

One interesting cross-sectional property of the baby boom is that its size was larger among richer households. As demonstrated in Figure 2(a) the size of the baby boom was 0.79 children for

the whole population. However, the women in the bottom half of the income distribution only had a baby boom of 0.70 children, while the women in the top half of the income distribution had 0.88 more children during the baby boom. This property would be even more evident if the magnitude of the baby boom is measured by fertility increase in percentage. As demonstrated in Figure 2(b), while the completed fertility rate increases by 33% for the whole population, it only increases by 27% for the poor, and by 40% for the rich. This is due to the fact that the fertility of the rich was much lower than the poor before the baby boom. Because of the differential magnitudes of the baby boom by income, the fertility differential between the rich and the poor shrinks over the baby boom period, which is one of the main findings in Jones and Tertilt (2007). Figure 12 demonstrates the model results. I find that the rich do have a larger baby boom than the poor in the model. When the debt policy hits, the rich increase their fertility by 20% while the poor's fertility only rose by 12%. As I argued earlier, this result is driven by the progressivity of the income tax in the model. The logic is as follows. The progressivity of the taxation system implies that the rich share a proportionally larger part of the tax burden. Therefore, the reduction in the debt-GDP ratio benefits the children of the rich more than those of the poor (if children of the rich are assumed to be also relatively rich). This means that the utility of children of the rich will increase by more, which gives the rich parents greater incentive to increase fertility. Furthermore, the progressivity of labor income tax implies that the rich pay proportionally more to finance the drop of the debt-GDP ratio. Thus, the opportunity cost of child-rearing drops more for the rich, which also gives them greater incentive to increase fertility.

Overall, my model can generate very good qualitative results. However, it is also obvious that the model cannot account for the entire baby boom. The baby boom generated in this model is approximately 47% of the one observed in the data. Since there are more than one mechanism going on behind the baby boom, I consider explaining 47% of the baby boom a success. In the next section, I do sensitivity analysis to examine the robustness of the results.

7 Sensitivity analysis

As I mentioned above, the curvature on the number of children, θ , is a key parameter in our model. It directly affects the size of the baby boom in this model. However, there is no empirical estimate for it in the existing literature. In the benchmark calibration, I choose the value of θ so that the model can match the income elasticity of fertility among the cohort of women born between 1911 and 1915. In this section, I do sensitivity analysis for θ to see how our results change with respect to different values of θ . I find that a higher value of θ will generate a larger baby boom. For each value of θ , I recalibrate the model to match all the targets used in the benchmark calibration except the income elasticity of fertility. Figure 13 demonstrates the magnitudes of the baby boom in the model with respect to different values of θ . A value of 0.8 generates a baby boom of 0.63, which is almost 80% of the one observed in the data. A value of 0.2 for θ generates a baby boom of 0.27, which accounts for 34% of the postwar baby boom in the U.S. I can see that even with a very low value of θ , my model is still able to explain a significant portion of the baby boom. This increases my confidence in the argument that the drop of the debt-GDP ratio after WWII was an important factor causing the postwar baby boom in the U.S.

8 Conclusion

In this paper, I study the role government debt played in generating the postwar baby boom in the United States. I find that the dramatic reduction in the government debt-GDP ratio after WWII was an important cause of the baby boom in the U.S. The reduction in the debt-GDP ratio affects people's fertility choice through two mechanisms. First, a reduction in the debt-GDP ratio changes the tax burden of different generations: it raises the current income tax rate and implies a lower tax burden on children in the future. A higher current income tax rate raises fertility by lowering after-tax wage and therefore the opportunity cost of child-rearing (when the cost of child-rearing involves parental time). A lower tax burden on children in the future raises the children's

lifetime utility, which also raises current fertility if the parent has Barro-Becker type preferences (the children's utility is included in the parent's utility function).

The second mechanism works via the capital-labor ratio. Government debt (internal debt) has crowding out effect on aggregate capital (see Diamond (1965)). Therefore, the drop of the debt-GDP ratio boosts the aggregate capital level and raises the capital-labor ratio, which in turn implies higher wage rates and lower interest rates in next period through general equilibrium effects. Lower interest rates raise fertility by inducing parents to substitute their old-age savings for children. Higher wage rates raise children's utility, thus it also raises fertility in the same way as lower future tax burdens. These two mechanisms worked together and contributed to the postwar baby boom in the U.S.

The quantitative exercise shows that, with reasonable parameter values, my model explains half of the postwar baby boom in the U.S. Furthermore, my model also well matches an interesting cross-sectional property of the baby boom: the size of the baby boom was much larger among richer households (documented in Jones and Tertilt (2007)). I argue that the progressivity of the U.S. income tax system is the reason for this cross-sectional property of the baby boom.

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9 Appendix 1: A Model with Intergenerational Transfer

I now think about an economy in which parents are allowed to leave intergenerational transfers to their children. For simplicity, we assume away the old-age period. In other words, agents only live for two periods: childhood and adulthood. Now each adult in period t faces the following problem.

$$V_t = \max_{c,n} u(c_t) + \beta n_t^\theta V_{t+1} \quad (18)$$

s.t.

$$c_t + n_t b w_t (1 - \tau_t) + n_t a_{t+1} = w_t (1 - \tau_t) + (1 + r_t) a_t, \quad (19)$$

where a is the intergenerational transfer, which could be either bequest or human capital investment.

Following Barro and Becker (1989), we reformulate the problem as a dynastic problem.

$$V_0 = \max_{c,n} \sum_{t=0}^{\infty} \beta^t (N_t)^\theta u(c_t) \quad (20)$$

s.t

$$c_t + n_t b w_t (1 - \tau_t) + n_t a_{t+1} = w_t (1 - \tau_t) + (1 + r_t) a_t, \forall t, \quad (21)$$

where $N_t = \prod_{i=0}^{t-1} n_i$ for $t = 1, 2, \dots$ ($N_0 = 1$) is the number of adults in period t . The standard first order conditions are as follows,

$$\frac{u'(c_t)}{u'(c_{t+1})} = \beta (1 + r_{t+1}) n_t^{\theta-1}. \quad (22)$$

$$(\theta + \sigma - 1) u(c_t) = u'(c_t) [b w_{t-1} (1 - \tau_{t-1}) (1 + r_t) - w_t (1 - \tau_t)]. \quad (23)$$

Assuming $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, and equation (22) can be rewritten as,

$$c_t = \frac{1 - \sigma}{\theta + \sigma - 1} [b w_{t-1} (1 - \tau_{t-1}) (1 + r_t) - w_t (1 - \tau_t)]. \quad (24)$$

Combining (21) and (23),

$$\frac{b w_{t-1} (1 - \tau_{t-1}) (1 + r_t) - w_t (1 - \tau_t)}{b w_t (1 - \tau_t) (1 + r_{t+1}) - w_{t+1} (1 - \tau_{t+1})} = (\beta (1 + r_{t+1}))^{-1/\sigma} n_t^{(1-\theta)/\sigma} \quad (25)$$

Equation (25) tells us that how the current fertility is determined. The following proposition states how the tax rates affect the current fertility decision in the model with intergenerational transfer.

Proposition 3: *Under the standard assumptions of the Barro-Becker model: 1) $0 < \theta < 1$; 2) $0 < \sigma < 1$; 3) $\theta + \sigma > 1$; 4) children are a net financial burden to altruistic parents, the following two statements are true:*

1. $\tau_t \uparrow \Rightarrow n_t \uparrow$

2. $\tau_{t+1} \downarrow \Rightarrow n_t \uparrow$.

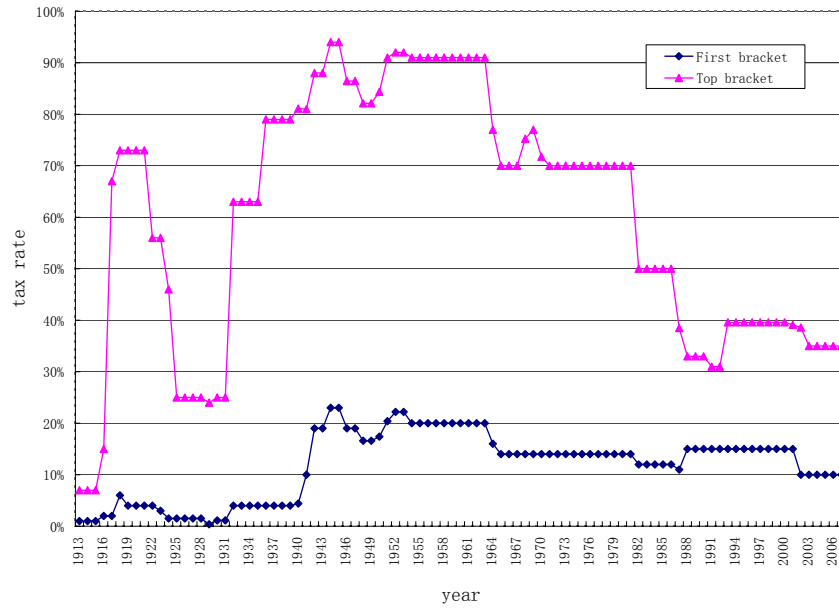
3. $w_{t+1} \uparrow \Rightarrow n_t \uparrow$.

4. $r_{t+1} \downarrow \Rightarrow$ *the change in n_t is ambiguous*.

Proof: The proofs for the first three statements are similar with the proofs for proposition 2. The effects of $r_{t+1} \downarrow$ on n_t are twofold: 1) a lower r_{t+1} means that it is more expensive for the parents to increase the quality of children, therefore the parents substitute the quality of children for the quantity of children; 2) a lower r_{t+1} means that the cost of having a child with a given amount of transfer is higher, which has a price effect on fertility. The net effect is ambiguous, which depends on the parameter values.

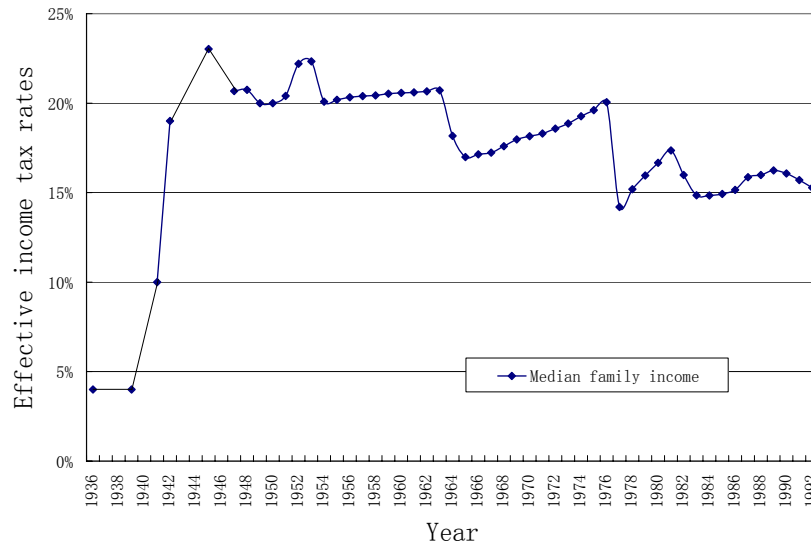
10 Appendix 2: The Algorithm

Figure 2: Labor income tax rate in the U.S.:1913-2007.



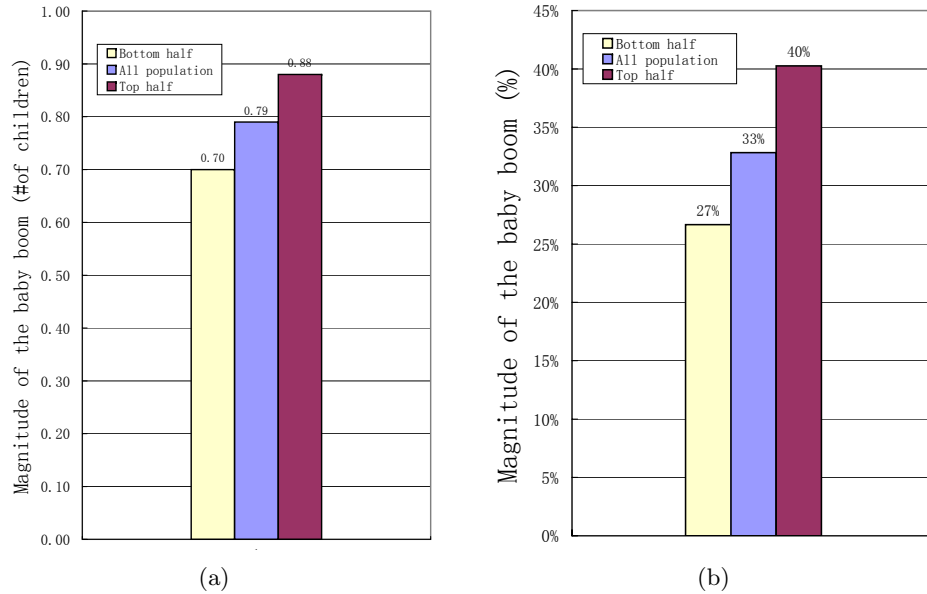
(Data source: Census (1913-1970), Internal Revenue Service (1971-2007))

Figure 3: Effective income tax rate for the median income family in the U.S.



(Data source: 1. median income: Bureau of Census; 2. income tax rates: Tax Foundation.)

Figure 4: Cross-sectional properties of the baby boom



(Data source: Jones and Tertilt (2007))

Figure 5: Government expenditures as % of GDP in the U.S..

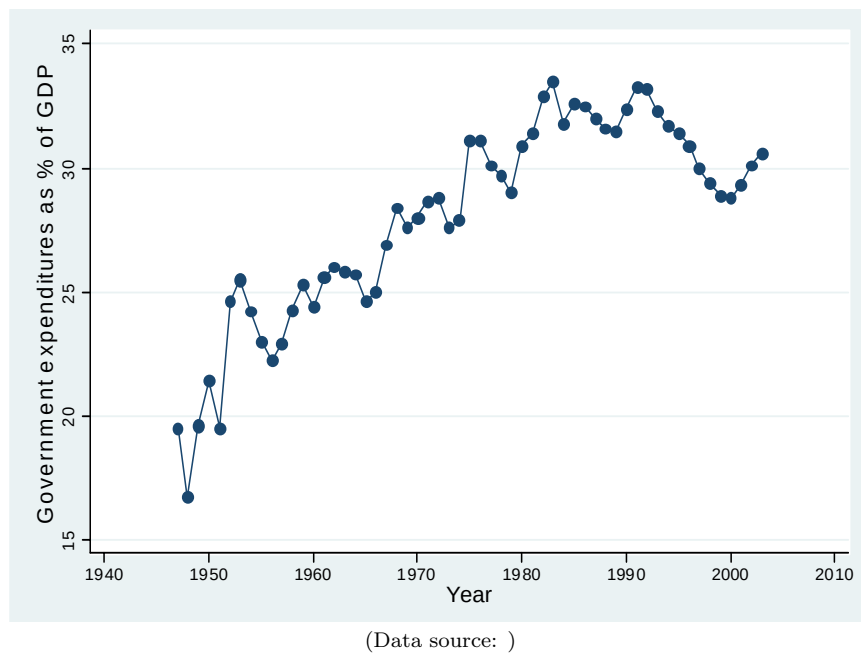


Figure 6: The government debt-GDP ratio in the first group of countries

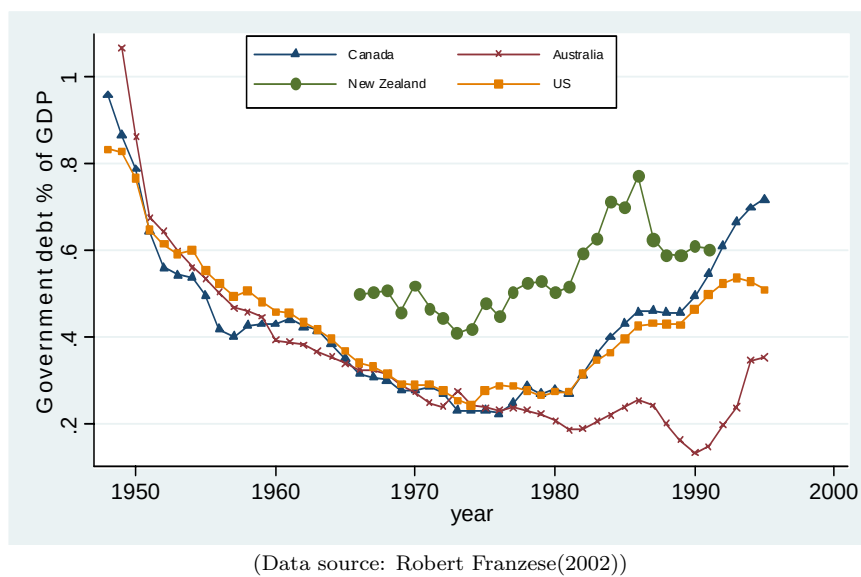


Figure 7: The government debt-GDP ratio in the second group of countries

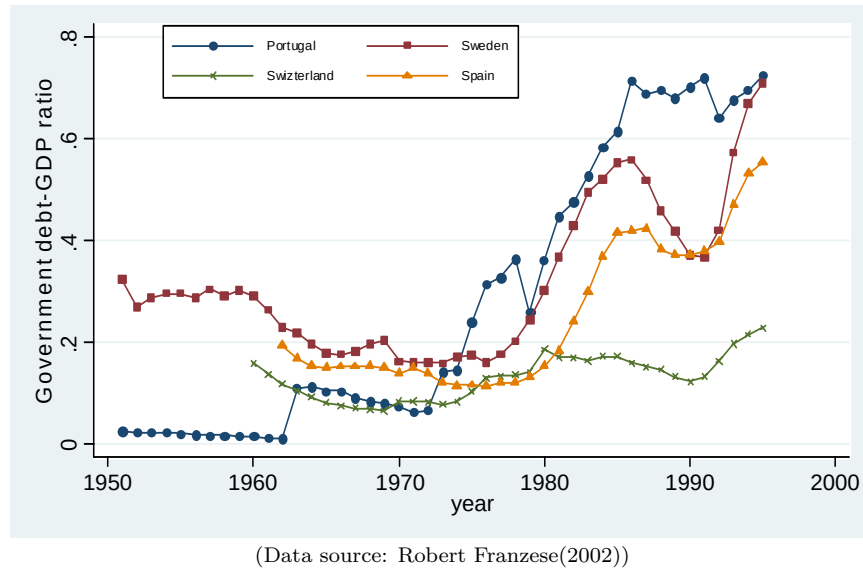


Figure 8: Completed fertility rate in the first group of countries

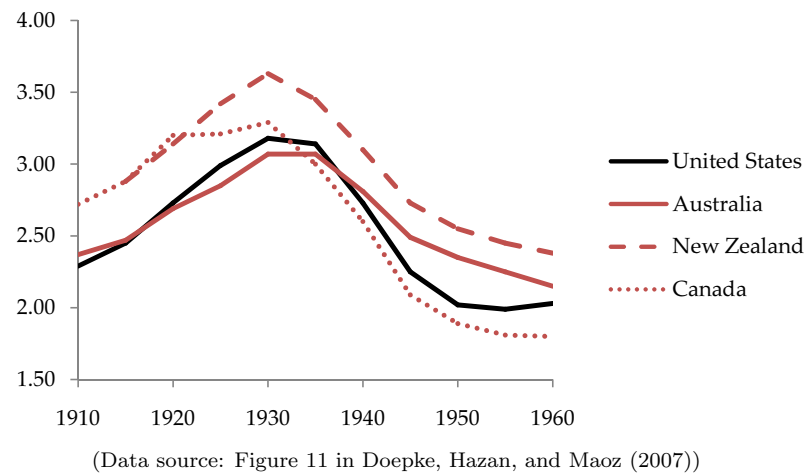


Figure 9: Completed fertility rate in the second group of countries

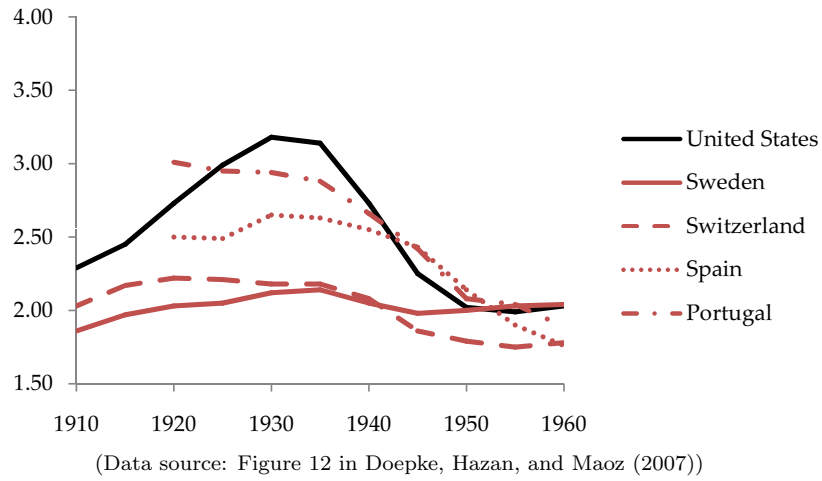
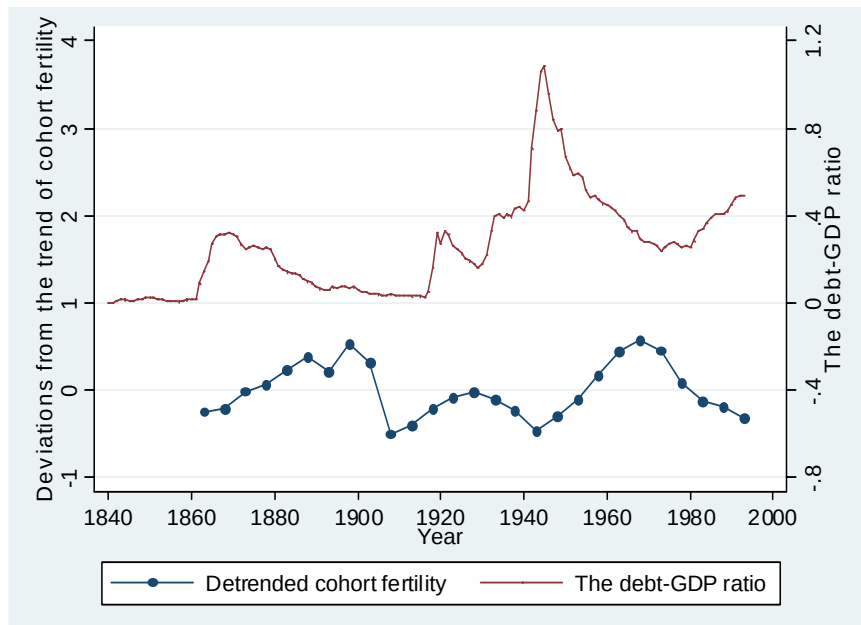
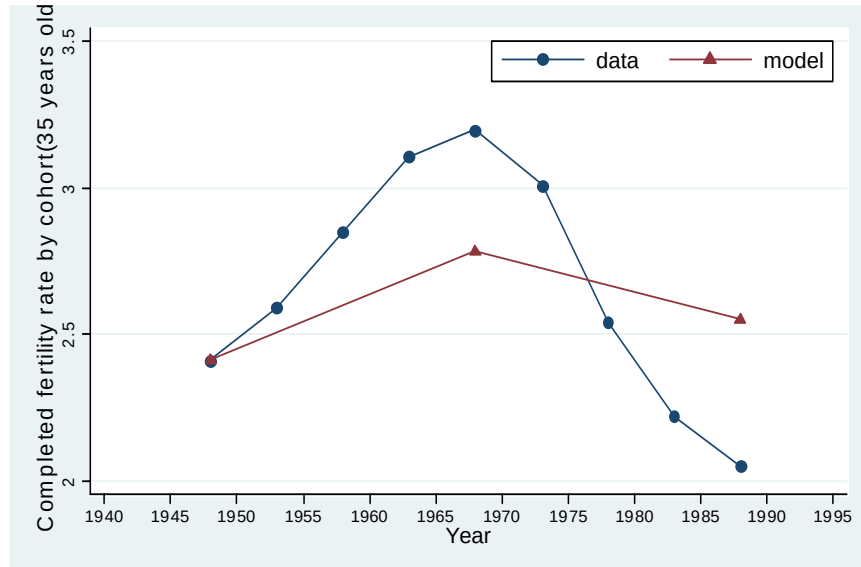


Figure 10: The debt-GDP ratio and detrended lifetime fertility in the U.S.(since 1840).



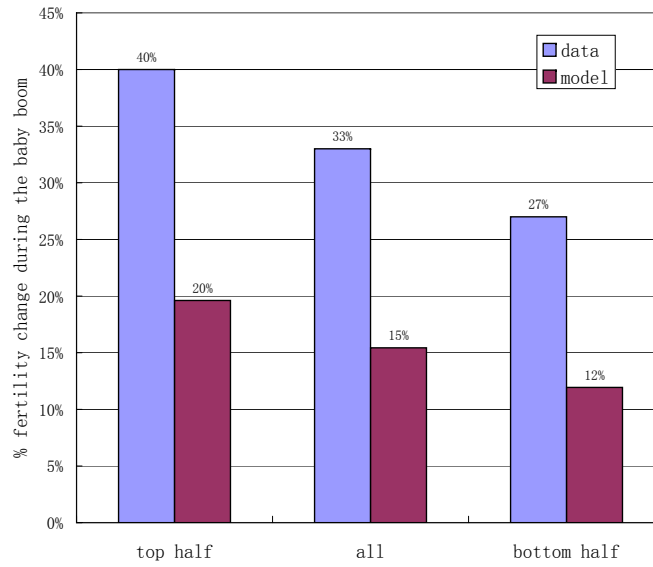
(Data source: 1. debt-GDP ratio: OMB/Budget of the U.S. Government (since 1940), derived by the author from the data provided by U.S. Bureau of the Census and <http://www.measuringworth.org> (before 1940); 2. cohort fertility: Jones and Tertilt (2007).)

Figure 11: The fertility rate on the transition path (benchmark calibration)



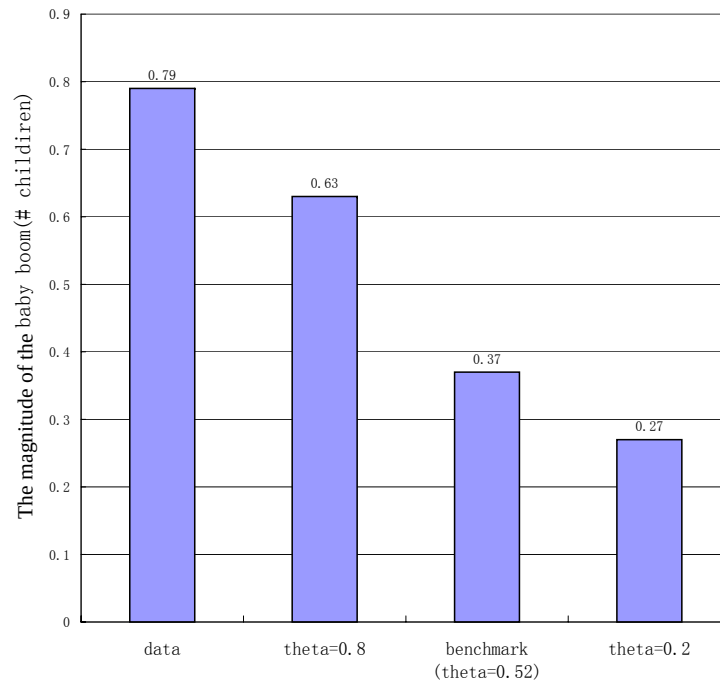
(Data source: Jones and Tertilt (2007))

Figure 12: Cross-sectional properties of the baby boom



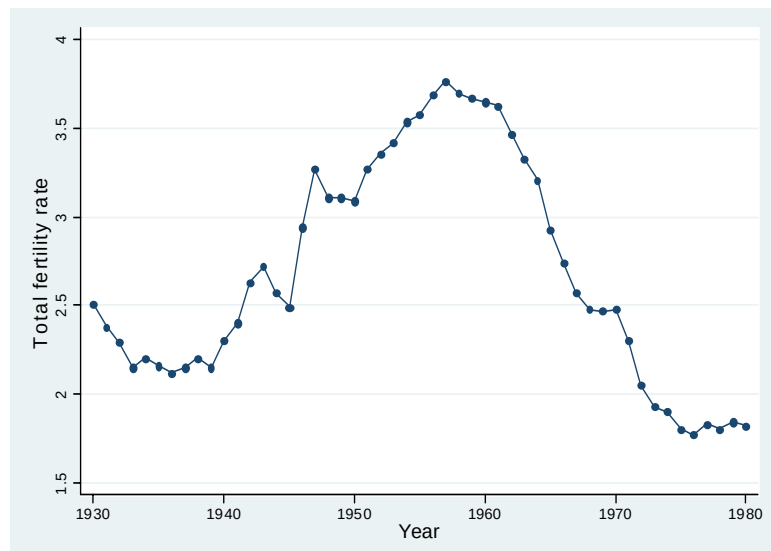
(Data source: Jones, and Tertilt (2007))

Figure 13: Baby boom w. r. t. different values of θ



(Data source: Jones and Tertilt (2007))

Figure 14: The total fertility rate in the U.S..



(Data source: Chesnais (1992).)