

**ESSAYS ON PUBLIC FINANCE:
RETIREMENT BEHAVIOR AND DISASTER RELIEF**

by

Thomas Eisensee



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MAIL ADDRESS:

STREET ADDRESS:

S-106 91 STOCKHOLM, SWEDEN

Universitetsvägen 10 A, 8th floor

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ABSTRACT

This thesis consists of three self-contained essays. The first essay is an empirical analysis of the relationship between news coverage of disasters and the provision of disaster relief. The two last essays deal with the relationship between fiscal policy and the retirement decision.

News Droughts, News Floods and U.S. Disaster Relief studies the mass media's influence on the U.S. government response to approximately 5,000 natural disasters in developing countries in 1968-2002. These disasters took around 63,000 lives and affected 125 million people per year. Given the huge losses involved, it is essential that disaster relief is provided to those most in need. We show that U.S. disaster relief depends on the occurrence of other newsworthy events at the time of the disaster, such as the Olympic Games or the O.J. Simpson Trial, which are obviously unrelated to need. We argue that the only plausible explanation for this is that relief decisions are driven by news coverage of disasters, and that this news coverage might be crowded out by other newsworthy material.

Fiscal Policy and Retirement in the Twentieth Century proposes a model that explains the trend in labor supply among older workers through changes in fiscal policy, including social security. The model emphasizes the general equilibrium effects of fiscal policy on retirement behavior. In particular, the radical shift in fiscal policy at the beginning of the century raised the returns to savings, which induced workers to retire earlier. The model predicts a large change in the retirement age upon the introduction of social security, while subsequent increases in replacement rates are shown to have a small impact on retirement. Specifically, the retirement elasticity is found to be a decreasing and convex function of the replacement rate. The essay re-introduces social security as a major determinant of retirement behavior in the second half of the twentieth century, while simultaneously offering an explanation to the two main puzzles in the literature: (i) the small contemporary retirement elasticities and (ii) the drop in the retirement age prior to the introduction of social security.

Sustainable Fiscal Policy and the Retirement Decision concerns the sustainability of fiscal policy in aging economies and the retirement decision. The essay develops an applied general equilibrium overlapping generation model calibrated to the U.S.

economy, where retirement behavior is endogenous and current fiscal policy is a response to future demographic developments. Three distinguishing sustainable policies are analyzed: (1) raising taxes only (2) reducing the replacement rate only and (3) raising the Full Retirement Age (FRA) only. All policies are found to have a substantial impact on retirement behavior. In particular, sustaining fiscal policy will result in falling interest rates, inducing a general delay in retirement. This general equilibrium effect on retirement behavior can be substantially larger than the direct effect of changing social security incentives. However, although the delay in retirement reduces the burden of an aging population, the required fiscal adjustments are large. The reason is that U.S. social security is roughly actuarially fair, which implies that delayed retirement only has a small effect on public coffers.

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Chapter 1

Introduction

This thesis consists of three self-contained essays on public finance. The first essay is an empirical analysis of the relationship between news coverage of disasters and the provision of disaster relief. The two last essays deal with the relationship between fiscal policy and the retirement decision, and are closely related in terms of the theoretical and methodological framework used.

News and Disaster Relief Do news stories affect politics? This question has occupied researchers in political science and economics for decades. In general, it is difficult to verify whether a news story affects politics. First, we do not know the counterfactual, i.e. whether the political system would have acted in the same way in the absence of the media story. Second, even if we can find an experiment where such a counterfactual exists, it is unclear whether causality can be established. For example, media coverage could be an outcome of the policy rather than the determinant.

In *News Droughts, News Floods and U.S. Disaster Relief* we study how news stories on disasters affect the provision of disaster relief. This is an important study in its own right: each year disasters take around 63,000 lives and affect 125 million people. It is important to understand whether media influences the allocation of relief to disaster victims. In addition, disaster relief provides a unique opportunity to study the effect of mass media on politics. Disasters are arguably exogenous events that are reasonably well-documented and regularly covered in the media. It is therefore, in principle, possible to find counterfactuals. However, larger and more severe disasters are both more likely to be in the news and receive relief. This does not necessarily imply causality. Even controlling for the severity of a disaster (killed, affected etc.) it is unclear whether the remaining correlation is due to news or other

features of the disasters for which we are unable to control for (e.g. the salience of a disaster).

In the essay, we propose to use the availability of other newsworthy events, for instance the Olympics or the O.J. Simpson trial, to establish causality. We construct two measures to capture the availability of other newsworthy events: *Olympics* and *news pressure*. We argue that these measures are exogenous both to news coverage of a disaster and relief decisions, but affect the media's decision of whether to cover a disaster. The measures therefore allow us to establish causality. In particular, we show that when other newsworthy events take place, the likelihood that media will cover a disaster decreases. That is, the availability of other newsworthy events crowds out news coverage of disasters. Moreover, the probability that a disaster receives relief drops. Thus, we argue that relief decisions are driven by news coverage of disasters, and that this news coverage is crowded out by the availability of other newsworthy material.

Quantitatively, disasters are, on average, around five percent less likely to receive relief if they occur during the Olympics than during other times and around eight percent less likely to receive relief when *news pressure* is at its highest level relative to its lowest level. Using another metric, a disaster occurring during the Olympics must have three times as many casualties as a disaster on an ordinary day to have the same chance of receiving relief. Similarly, a disaster occurring when *news pressure* is at its highest level must have six times as many killed as a disaster occurring when *news pressure* is at its lowest level, all else equal. These findings hold up in a large array of robustness checks.

The essay is an important contribution to the literature on media and politics, and to the literature on disasters and disaster relief.

Fiscal Policy and the Retirement Decision The last two essays of the thesis are concerned with the relationship between fiscal policy, including social security, and the retirement decision. They are motivated by the ongoing discussions of reforms of social security in developed economies. These reforms potentially have a great impact on retirement decisions and understanding the nature and size of this effect is crucial. The essays are closely related theoretically as well as methodologically. They make use of an applied general equilibrium model, where individuals make optimal decisions on consumption, savings, and hours worked over their lifecycle. A key feature is that individuals also make optimal choices about their retirement age. The models are calibrated to capture stylized features of the U.S.

economy, including the U.S. social security system.

Fiscal Policy and Retirement in the Twentieth Century takes a historical look at the retirement decision. By some accounts, the retirement age in the U.S. declined from around 78 in 1900 to 63 today. The trend is similar in other developed countries. Social security has often been proposed as the main determinant of the declining trend. However, two puzzles must be addressed by anyone arguing that social security is the causal factor. First, microeconomic studies tend to find a very small effect of social security on retirement behavior. Second, the decline in labor force participation started already in the early twentieth century, long before social security was introduced.

The essay proposes a model that explains the trend in labor supply among older workers through changes in fiscal policy, including social security. The model emphasizes the general equilibrium effects of fiscal policy on retirement behavior. In particular, the radical shift in fiscal policy, especially debt policy, at the beginning of the century raised the returns to savings, which induced workers to retire earlier. The model predicts a large change in retirement behavior upon the introduction of social security, while subsequent increases in replacement rates are shown to have a small impact on retirement. Specifically, the retirement elasticity is found to be a decreasing and convex function of the replacement rate. Thus, the essay proposes social security as a major determinant of retirement behavior in the second half of the twentieth century, while simultaneously offering an explanation of the two main puzzles in the literature.

Sustainable Fiscal Policy and the Retirement Decision takes a peek into the future. Current discussions about reforming social security are largely motivated by demographic developments, in particular, the rapidly rising old-age dependency ratios. In the U.S., for instance, the dependency ratio is expected to rise from 20% in 2000 to around 42% in 2050. The model developed here extends the model of the previous essay in two ways. First, the U.S. demographic transition is modelled in detail. Second, the model allows for heterogeneity in skills. The essay asks whether reforms to sustain fiscal policy are likely to have a substantial effect on retirement behavior and, if so, whether this is likely to ease the burden of the aging population. Three reforms to sustain fiscal policy are considered: (1) an immediate increase in taxes, (2) an immediate and universal reduction in replacement rates and (3) an immediate and universal increase in the Full Retirement Age (FRA). The essay finds that retirement behavior is likely to be considerably delayed by all policies. The main reason is that all reforms considered increase government savings,

thus reducing interest rates. This causes a general delay in retirement. Moreover, the essay shows that while changes in the replacement rate have a small effect on retirement behavior, changes in FRA have a large effect.

However, although the delay in retirement reduces the burden of an aging population, the required fiscal adjustments are large. The reason is that U.S. social security is roughly actuarially fair, i.e. the present discounted value of benefits is roughly the same irrespective of the choice of retirement age. This implies that delayed retirement only has a small effect on public coffers.

The essay also makes an important contribution by quantifying the costs of an aging population. In particular, it is shown that the current fiscal policy in the U.S. can be sustained by an increase in taxes of 5.5 percentage points, a reduction in replacement rates by 42% or an increase in FRA to the age of 73.

Both essays have important implications for the literature on social security and retirement behavior.

Chapter 2

News Droughts, News Floods and U.S. Disaster Relief^{*}

1 Introduction

In May 1999, a storm struck India, reportedly killing 278 people and affecting 40,000. On the same day, a 15-year-old sophomore shot and wounded six classmates at the Heritage High School in suburban Atlanta. The two events competed for news time. Since this was just a month after the Columbine high school tragedy, the events at the Heritage High School were extensively covered by the U.S. television network news, while the Indian storm was not covered. About one year earlier, a storm of similar size struck India (killing 250 and affecting 40,000 people). At that time, there was less other breaking news, and the storm was covered by the television network news. Two days later, the U.S. Ambassador in India, Richard F. Celeste, declared this storm a disaster, and its victims consequently received U.S. relief. However, he did not issue a disaster declaration for the first mentioned storm and there was no U.S. government relief.

This paper investigates whether television network news stories influence government policy making. Although network news is widely believed to be an important determinant of government policy, little conclusive evidence has been produced to this effect. Empirical studies have typically looked at the publication of a story, like the one above, and subsequent policy. Unfortunately, we do not know what would have happened in the counterfactual case, i.e. if there had been no publication. It may be that policy makers would have acted in the same way had the media not

^{*} This paper is joint with David Strömberg. We thank Torsten Persson, Ethan Kaplan, James Hamilton, Stefano Dellavigna and Fabrizio Zilibotti for helpful comments and suggestions, and Christina Lönnblad for editorial assistance.

published the story. Although one incident, like the one above, cannot conclusively show that media affects policy, a study of a large number of similar events can overcome this difficulty. We will show that above pattern is not just an isolated event but part of a systematic pattern in the data; a pattern which would be very unlikely if media did not affect policy.

In this paper, we will study mass media's influence on the U.S. government response to natural disasters in developing countries. The incidence and severity of natural disasters are arguably an exogenous process that generates newsworthy and reasonably well documented events. We study approximately 5,000 natural disasters in developing countries between 1968 and 2002. These disasters were identified and documented by the Centre for Research on the Epidemiology of Disasters (CRED). On average, 150 natural disasters occurred each year during the period taking around 63,000 lives and affecting 125 million people. According to our estimates, about 10 percent of these natural disasters were covered in the television network news and 20 percent received relief from USAID's Office of Foreign Disaster Assistance (OFDA).¹ This was found after analyzing the contents of the evening news broadcasts of the U.S. major networks (ABC, CBS, NBC, and CNN), data provided by the Vanderbilt News Archives, and relief data from OFDA.

The obvious problem in establishing the impact of news on relief is that more severe disasters are both more likely to be in the news and to receive relief. We attack this problem by using the availability of other newsworthy² material as an instrument for whether the disaster was in the news. In other words, we are asking whether a natural disaster is less likely to receive relief because news about this disaster was crowded out by news about, for example, the shootings at the Heritage High School, the Olympics, or the O.J. Simpson trial. Equally important, we also study whether disasters of more moderate size are more likely to receive relief simply because they appeared on the evening news since there was little other news around.

We use two measures of the availability of newsworthy material. One is solely based on the dates of the Olympic Games. The Olympics produce newsworthy material during specific dates. The bulk of the 2,400 news stories about the Olympics that we identify are aired during the games. We will use the average number of days immediately following a disaster that falls within the duration of the Olympics as

¹ We thank OFDA and Wesley Mossburg for providing the data and other information throughout the project.

² We will use the term "newsworthy" to mean the audience appeal of the news as perceived by the media.

an instrument for news coverage of disasters.

The other measure is the amount of time spent on the top three news segments in a network news broadcast.³ When a large media event takes place, the story is usually placed as one of the first news stories in a broadcast and devoted a great deal of time. For instance, on October 3, 1995, a jury found O.J. Simpson not guilty of two counts of murder. That night, the ABC, CBS and NBC devoted all their first three news segments to that story. The top three news segments comprised an average of 16 minutes and 30 seconds – the highest value of that year. In comparison, the average amount of time spent on the top three news segments in 1995 was 7 minutes. The Simpson verdict effectively crowded out other news. NBC *only* covered this story, while CBS also reported one other story (stock market report) and ABC included 4 other stories. Since disaster news is often broadcast after the day the disaster struck, we average this measure over the days following the disaster strike date. We call this variable *news pressure*.

We argue that when there is plenty of other newsworthy material available, then natural disasters in foreign countries are crowded out from network news broadcasts and, consequently, are less likely to receive U.S. relief. There is no particular reason to believe that the severity of natural disasters in foreign countries is related to the availability of other news. Still, U.S. Ambassadors – who are typically responsible for disaster declarations – are less likely to declare disasters during the Olympics and during times when U.S. *news pressure* is high (see Figure 2.1). We will show that these correlations remain after accounting for the number of killed and affected, as well as fixed effects for disaster type, month, year and country.

A potential problem is that *news pressure* may be directly affected by the publication of disaster news. If disaster news is placed among the top three stories, this will generate a positive correlation between news pressure and the severity of the disaster. If news about the disaster is placed outside the top three, it might cause less time to be devoted to the top three segments, inducing a negative correlation. This concern is addressed in two ways. First, we remove all days when any disaster story was aired from the 40-day average. This has a minimal impact on the estimated coefficients. Next, we intentionally bias *news pressure* by adding all news time devoted to disaster stories to the time devoted to the top three news segments. In reality, the news time freed up by not airing the disaster news would partially be allocated to news segments outside the top three. Even this extreme induced bias

³ This instrument is related to that used in Erfle and McMillan (1990), i.e. the weekly average percentage of total news time devoted to the two leading non-energy news topics.

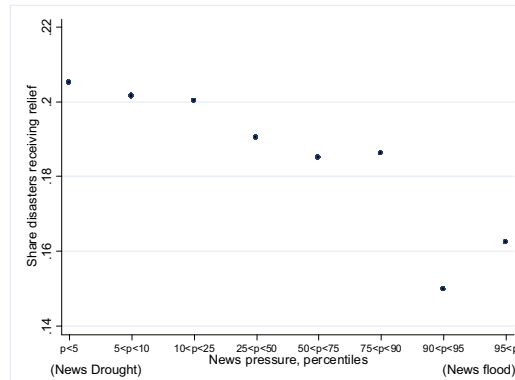


Figure 2.1: Share natural disasters receiving OFDA relief, by domestic US news pressure

has little influence on our estimated coefficients.

This paper is closely related to recent work studying how mass media penetration affects government policy. Strömberg (1999, 2004) finds that U.S. counties with higher levels of radio ownership were more successful in attracting New Deal spending. Similarly, Besley and Burgess (2002) find that government relief programs were more responsive to droughts and floods in Indian states with a higher newspaper circulation. The question we ask is instead: Given media penetration how large is the effect on government policy of publishing a news story?

This question has long been studied by political scientists. For an overview, see the chapter "The Media As Policy Makers" in Graber (1997). As mentioned earlier, this literature has not been successful in identifying the media's policy influence. It has, however, identified a number of empirical pitfalls. For example, Cook et al. (1983) study the policy effect of media exposure of fraud and abuse in a Home Health Care program in Chicago. The researchers were informed in advance that a news story would be broadcast and had the opportunity of interviewing people pre- and post publication. They found that the publication changed politicians' and the general public's views and was eventually followed by a change in the legislation. However, it turned out that the news story was initiated by politicians seeking policy change, so it is questionable whether the news story actually caused the policy change. This illustrates a generic problem in identifying media effects: politicians use the media to pursue policy goals. In the context of our paper, policy makers may make the press aware of disasters to which they want to send relief to, creating a spurious correlation between coverage and subsequent relief.

Another problem is that, even perfectly controlling for the severity of the disaster, media coverage will be correlated with relief because both are driven by the unobservable salience of the disaster to the American public. This is nicely illustrated by Drury, Olson and Van Belle (2005). Their paper is very closely related to ours in studying the empirical allocation of U.S. foreign disaster assistance 1964-1995. They conclude that foreign policy and domestic factors are the overriding determinants of this allocation. Of particular interest with regard to our paper, they find disaster relief to be positively correlated with the salience of the disaster, measured by the amount of media coverage. Our instrumental variables approach avoids both these pitfalls since the availability of other newsworthy material is unrelated to the salience of disasters and politicians' policy goals regarding disaster relief.

While media coverage is found to affect disaster relief, we do not uncover the exact mechanism through which occurs. In general terms, disaster relief typically delivers favorable publicity,⁴ which can be enjoyed by policy makers providing relief to disasters covered in the news. But this is consistent with a number of theories. First, voters may evaluate politicians based on issues recently covered by the media (McCombs and Shaw, 1972). Thus, if a disaster was recently covered in the media this may enhance the salience of the issue at the ballot box. Second, politicians have a stronger incentive to act when voters can observe their actions through the media, since observable actions have a stronger influence on subsequent votes (Strömberg, 1999). Third, voters may respond to news stories by directly trying to influence their representatives directly (Public Action). In all cases, it is assumed that the government official taking the relief decision cares about the politicians' electoral support. The reason could either be that the government official cares about the funding of the relief program (see Niskanen, 1971), and this is increasing in its political popularity, or that the official's future career depends on how skillfully she manages the relief program in the politicians' interest (see Alesina and Tabellini, 2005). In Appendix 1, the Public Action and Voter Information models of disaster relief are developed and described more in more detail.

The paper is organized as follows. Section 2 discusses the background and data, while section 3 discusses the results. Then, section 4 discusses what continents and disaster types are more likely to receive relief because of the media effects, and also

⁴ For instance, Adamson et al (1998) find that 59% of the U.S. population support U.S. foreign economic assistance and that 30% believe that foreign disaster relief should be given the highest priority in U.S. foreign aid policy. The average priority given to foreign disaster relief was 7.4 on a 0-10 scale.

offers concluding remarks.

2 Background and Data

This section presents the data on disasters, disaster relief and television news. Table 3 provides summary statistics of our data.

2.1 Disasters

We use data on natural disasters from the Emergency Disaster Database (EDD) as provided by the Centre for Research on the Epidemiology of Disasters (CRED). In this database, an event qualifies as a disaster if at least one of the following criteria are fulfilled: 10 or more people are reported killed; 100 or more people are reported affected, injured and/or homeless; there has been a declaration of a state of emergency; or there has been a call for international assistance. We measure the severity of a disaster by two variables: the number of killed, denoted *killed*, and the total number of affected, denoted *affected*. The variable *killed* are persons confirmed dead and persons missing and presumed dead. The variable *affected* is the sum of "injured",⁵ "homeless"⁶ and "affected"⁷ as reported in EDD. The data provided in EDD is based on official figures when available.⁸

We analyze a subsample of this disaster data. To avoid some endogeneity problems, we restrict attention to natural disasters. Thus, we do not consider complex emergencies⁹ and technological disasters (eg. airplane crashes). We also drop the 40 observations on disasters that occurred prior to August 5, 1968, the date when the Vanderbilt Television News Archives started collecting data. Since, for the purpose of this study, it is important to know the date of the disaster, we drop 408 observations for which we only have information about the year of the event. Finally, since our specification allows for country fixed effects, we only include countries with more than one disaster and which has received OFDA relief at least once. For this reason, we drop 1,104 observations.

⁵ People suffering from physical injuries, trauma or an illness requiring medical treatment as a direct result of a disaster.

⁶ People needing immediate assistance in the form of shelter.

⁷ People requiring immediate assistance during a period of emergency, i.e. requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance.

⁸ CRED's source ranking is as follows: UN, US government, local government, IFRC, Research Centres, Lloyds Casualty Week, Reinsurance, Press, Private.

⁹ Manmade disasters (complex disasters) raise other non-trivial issues (type of war, safety for aid workers etc) which are beyond the scope of this paper.

This leaves us with a total of 5,212 natural disasters, occurring in 143 countries in 1968-2002. On average, 150 natural disasters occurred each year taking around 63,000 lives and affecting 125 million people. Each disaster on average had 590 casualties and affected the lives of 1.1 million people (see Table 1).¹⁰

The majority of natural disasters were caused by floods (32 percent), storms (23 percent) or epidemics (14 percent). Droughts took most casualties and affected most people per incident. Fires and floods caused the fewest casualties per incident, while infestations had the smallest number of affected.

There is a slight downward trend in the severity of disasters as measured by the mean number of *killed* and *affected*. This is partly driven by improvements in data collection procedures towards the end of the sample period, which has increased the availability of data on less severe disasters.

2.2 U.S. Emergency Relief and OFDA

The U.S. is the largest provider of emergency and distress relief by far, accounting for around a third of the total emergency aid provided by OECD countries to developing countries. In 2002, for instance, OECD countries provided USD 3,869 million in emergency and distress relief, of which the U.S. accounted for USD 1,382 million or 35.7 percent (OECD, 2005).

We will study disaster responses by the Office of Foreign Disaster Assistance (OFDA) over the period 1968-2002. The OFDA is an office within the U.S. Agency for International Development (USAID). It has been given flexible authority which permits it to respond quickly to the needs of disaster victims. Hence, it is generally the first U.S. agency to be on the scene of a disaster and it also influence other relief efforts. For example, the largest U.S. disaster relief program, under the Office of Food for Peace, requires an OFDA disaster declaration to trigger some of its disaster assistance. Although the OFDA only contributes around 20% of the total U.S. disaster relief, each dollar spent by the OFDA was matched by four dollars from other U.S. agencies in the fiscal year of 2002.

Our dependent variable, *relief*, indicates whether the OFDA provided relief to the disaster. Over the period 1968-2002, the OFDA responded to 19 percent of the disasters in the sample or, on average, 28 natural disasters per year.

¹⁰ Some disasters have missing values for *killed* and *affected*. Therefore, mean values refer to the sub-sample where observations exist. We treat 0-entries in *killed* and *affected* as missing values, after correspondence with CRED.

A disaster receives OFDA relief if and only if it is declared. A disaster can be declared by the U.S. Ambassador (the Chief of the U.S. Mission) in the affected country or, if a U.S. Mission is not located in the country, by the appropriate U.S. Assistant Secretary. A disaster declaration allows the Chief of Mission to allocate up to USD 50,000 (until 2002, USD 25,000) for host country relief efforts. Subsequently, USAID and the local mission jointly determine whether additional assistance for the disaster is warranted.

Disaster relief is intended to address *immediate* life threatening concerns (USAID, 2005). The disaster should meet three criteria: (1) it is of a magnitude with which the affected community cannot cope, (2) recognized representatives of the affected population desire the assistance and (3) it is in the U.S. Government's interest to respond.

The share of disasters to which the OFDA has responded differs substantially across disasters types, See Table 1. Infestations, droughts, and volcanos receive the highest response rates, while cold waves and land slides receive the lowest. As expected, the OFDA responds to disasters that are more severe than the average, with an average of 2,353 killed and 2.6 million affected.

2.3 News Coverage

Our explanatory variable of interest is U.S. news coverage of disasters. In this paper, we restrict attention to television news. Data on news coverage is taken from the Vanderbilt Television News Archive (VTNA). VTNA contains more than 30,000 individual network evening news broadcasts and 700,000 news stories from the major U.S. national broadcast networks (ABC, CBS, NBC, and CNN) since 1968.¹¹ News coverage is captured by an indicator variable, *news*, for whether a disaster was covered in a news broadcast within a certain timespan/window. In our benchmark specification, we use a window of -2 to +40 days, relative to the time of the event. Within this interval, a news segment is coded as covering a disaster if it contains certain keywords (country and type of disaster, eg. "earthquake"). For example, according to CRED, an earthquake occurred in Afghanistan on March 26, 2002. We code a disaster as being covered in the news if the headline or abstract in VTNA contains the words "Afghanistan" and "Earthquake",¹² and if the story was aired March 24-April 7, 2002 (-2,+40 days).

¹¹ CNN since October 1995 (before all were special programs).

¹² Generally more advanced boolean searches are conducted.

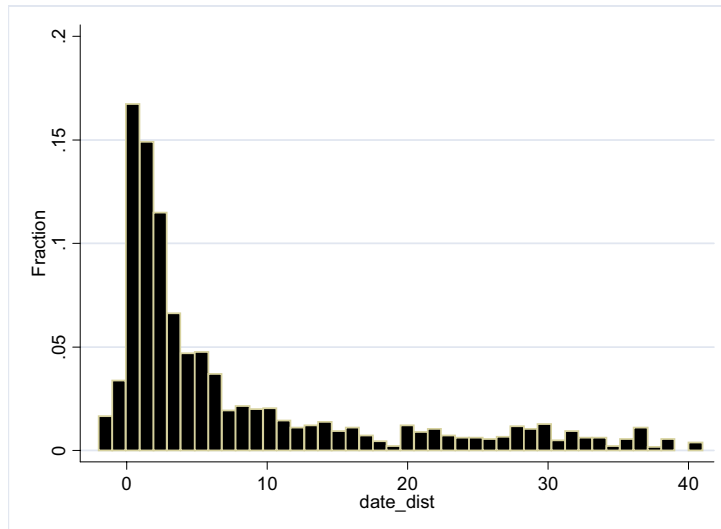


Figure 2.2: News stories on disasters, by days from the disaster

Network news covered around 10 percent of the disasters in our sample. Figure 2.2 plots the timing of the first news story on a disaster relative to the date of the disaster. The first news story is typically aired during the first days following the disaster. The likelihood of covering the disaster then falls rapidly until around 20 days after the disaster and then remains relatively constant.

2.4 Crowding Out of Disaster News

If two equally newsworthy disasters occur, we would expect that the disaster occurring when there is a great deal of other breaking news around would have a lower chance of being covered by the news than that occurring when there is little other news around. This crowding out is probably particularly strong for television news broadcasts that are usually of a fixed length (half an hour for ABC, CBS and NBC and one hour for CNN).

The challenge is to construct meaningful and operational measures of the availability of newsworthy material. Here, we implement two such measures. The first measure only depends on the dates of the Olympic Games. In our sample period, there are 18 Olympic Games, ranging from the 1968 summer Olympics in Mexico City to the 2002 winter games in Salt Lake City. The Olympics are well covered by the Network News. In our sample period, 2,443 news stories have "Olympic" in their headline. These stories are usually aired around the dates of the Olympic

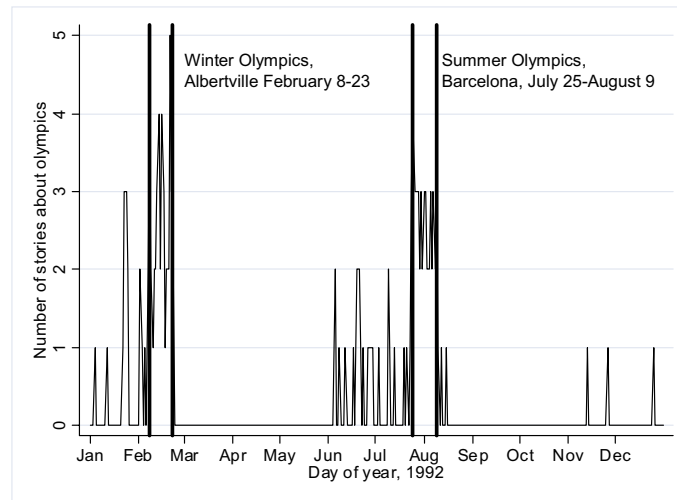


Figure 2.3: Daily number news stories about Olympic Games, 1992

Games. Figure 2.3 shows the daily number of network news stories covering the Olympics in 1992. The thick vertical lines mark the beginning and the end of the Olympic Games in Albertville February 8-23 and in Barcelona, July 25-August 9. As expected, news stories about the Olympics are mainly aired between these dates. On an average day during an Olympic Game, the network news broadcasts 3.6 news stories about the Olympics.

Below, we will investigate whether these stories crowd out news about natural disasters and whether this affects relief decisions. Natural disasters appear in the news not just on the day of the disaster, but also in the days following the disaster, see Figure 2.2. Consequently, we will use the average number of Olympic Game days directly following the disaster. Specifically, we will use the weighted average of days, where the weights are the empirical distribution of disaster news stories per day following the disaster, given by Figure 2.2. This weighted average variable will be called *Olympics*. Roughly 9 percent of the disasters in our sample (448 to be exact) occur when the variable *Olympics* is greater than zero.

Our second measure of the availability of newsworthy material is the median (across broadcasts in a day) number of minutes devoted by a news broadcast devotes to the top three news segments in a day (*daily news pressure*). When a large media event takes place, that story is usually placed as one of the first news stories in a broadcast and more time and/or news segments are devoted to the story. This suggests that the amount of time devoted to the first three news segments is a good indicator of how much newsworthy material is available on a given day. We use the

median value across news broadcasts in a day rather than the mean to reduce the effect of measurement error in the reported time for news segments.

One concern is that the *daily news pressure* is endogenous to stories about disasters, since the airing of a disaster story will affect the amount of time devoted to the top three stories. To diminish this problem, we will use the average of *daily news pressure* over the 40 days following the disaster in most specifications. This variable will be called *news pressure*. In the robustness section, we also report results when using the average weighted by the empirical distribution of disaster news stories per day following the disaster and the unweighted 20-day average.

Figure 4 plots *daily news pressure* from 1968 to 2003. We have marked the date with the highest value of *daily news pressure* for each year. The news stories corresponding to these dates are listed in Table 2 below. The table also lists the main stories corresponding to the second and third highest yearly values of *daily news pressure*. The overall highest value (90 minutes) was recorded for September 11, 2001. However, we coded September 11 as missing since the exceptional event extended the length of the news broadcasts. Note also that there is a slight upward trend in *daily news pressure*. This might reflect a general upward trend in the availability of breaking news stories or changes in the news technology. We will include year dummy variables in all regressions to pick up this type of variation. There is also seasonal variation in daily news pressure. There is an early summer news drought with exceptionally low *daily news pressure* in May and June, and news floods in the fall with higher *daily news pressure* in September and November. For this reason, we will include month-fixed effects in all regression.

Is *daily news pressure* a reasonable measure for the occurrence of newsworthy events? Figure 5 plots *daily news pressure* during 405 days (March 15 2001–April 23 2002). The horizontal flat line depicts the mean for the 1968-2002 period. The figure also displays the events occurring during the peaks of *daily news pressure*. Apparently, our measure captures the major events during these 405 days quite well, starting with the U.S.-China Spy plane incident (April 1 2001–April 11 2001), reaching its maximum around the September 11, 2001 terrorist attacks and ending with the Siege at the Church of Nativity in Bethlehem (April 2 2002–May 10 2002). Plots for other time periods do an equally good job in capturing major events. Also included in the graph is our 40-days average, *news pressure*. This measure puts an equal weight on all days during the 40 days. However, as discussed in section 2.3, most stories are aired within the first days following the strike date of the disaster.

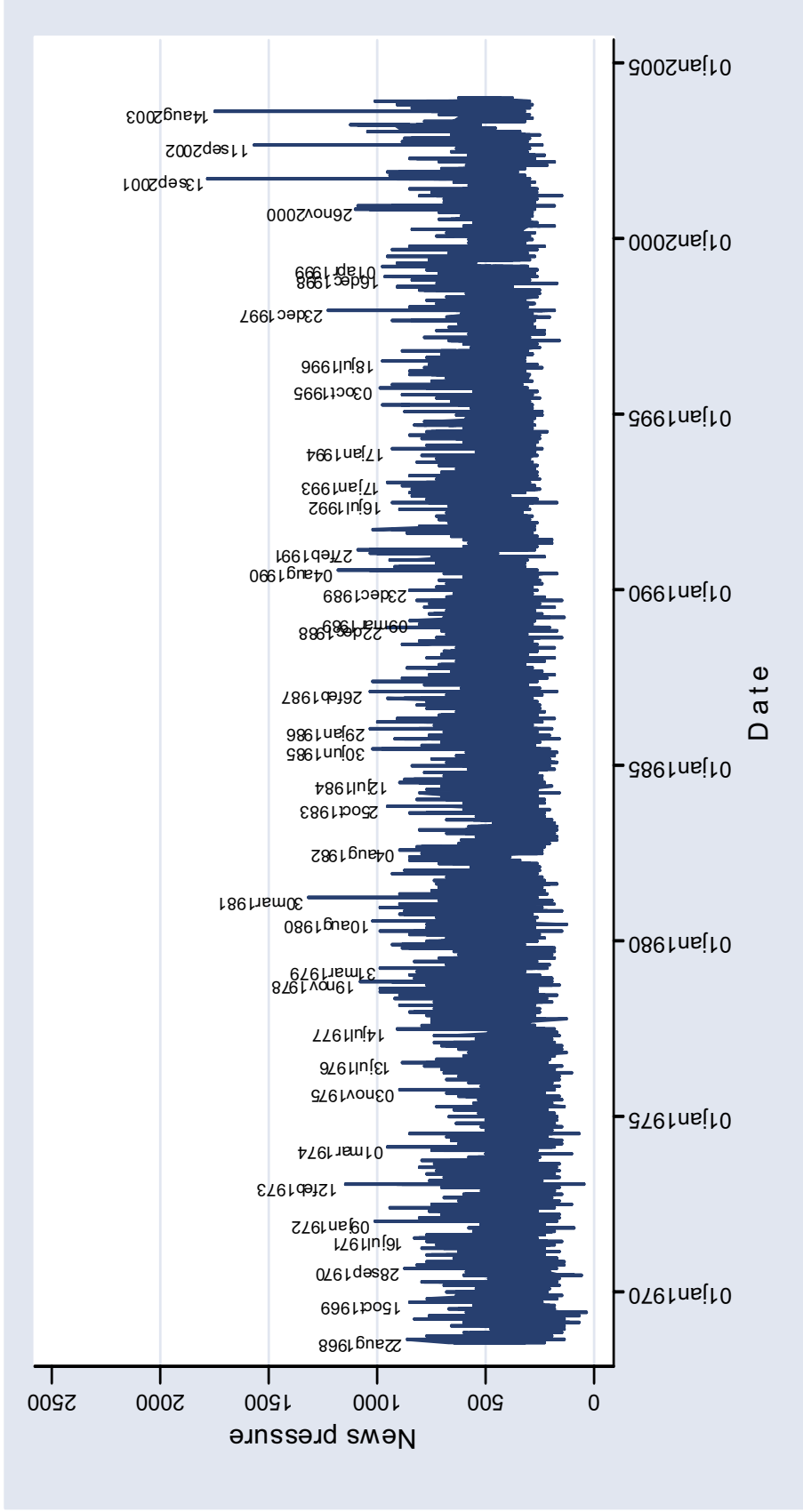


Figure 4: Daily news pressure (minutes), by day

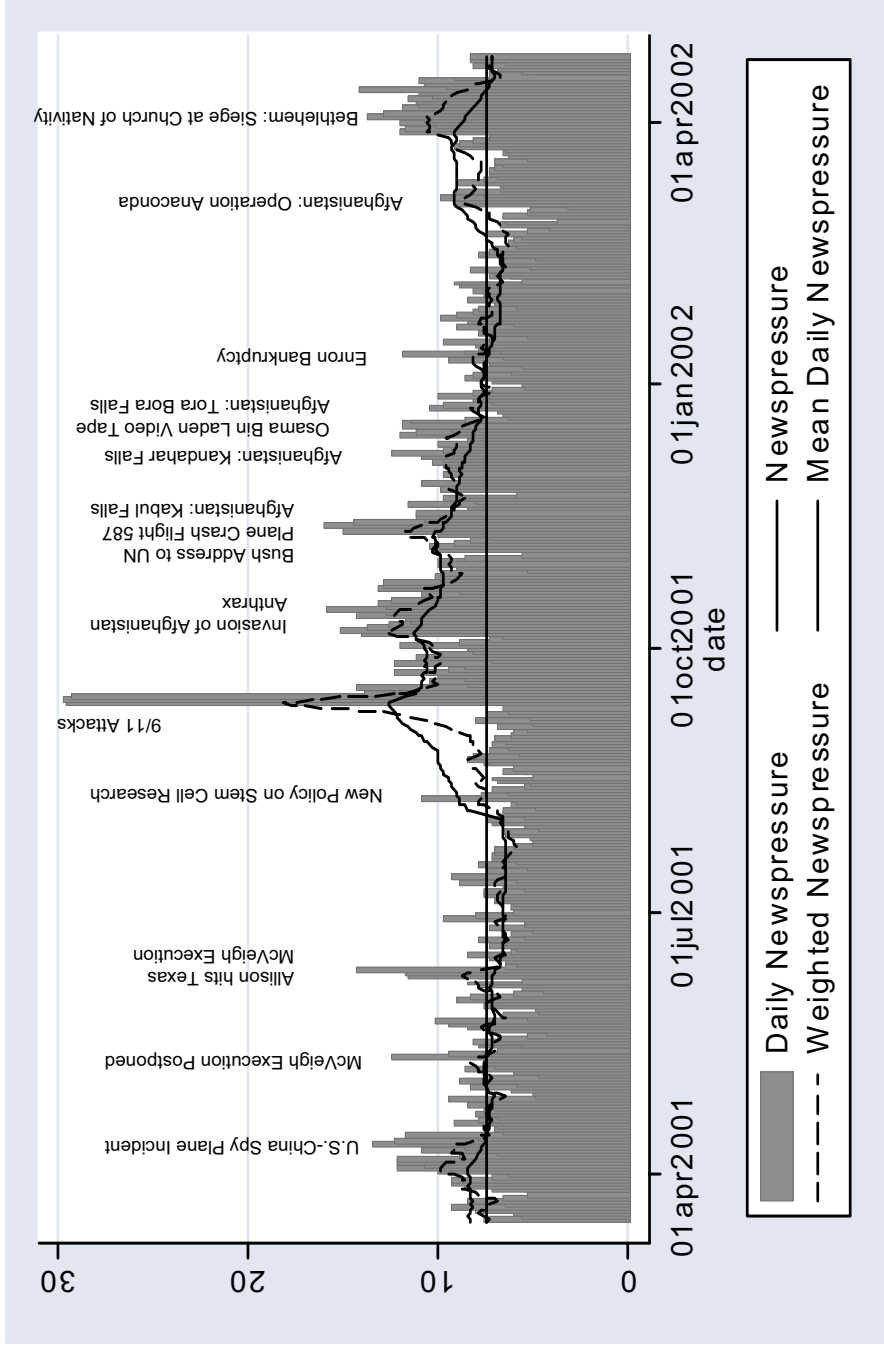


Figure 5: News Pressure (minutes) during 405 days, March 15 2001 – Apr 23 2002, by day

Therefore, we construct an alternative measure, *weighted news pressure*. Here, *daily news pressure* for each day during the 40-day period is weighted by the (ex-post) probability that the story appears on that particular day, i.e. the distribution plotted in Figure 2.2. The variable *weighted news pressure* is also plotted in Figure 5. Naturally, it is characterized by more pronounced peaks and troughs.

3 Results

This section contains our empirical results. First, we discuss the structure of the empirical model. For a formal model of the effect of news on relief, see the Appendix. Then, we analyze the empirical determinants of news and relief in detail. Finally, we discuss the robustness of the results.

3.1 Specification

Our econometric specification will be of the following form. For disaster i , the latent variable $relief_i^*$ (reliefworthiness) describes the benefits of providing relief from the decision maker's perspective,

$$relief_i^* = \alpha_1 news_i + \alpha' \theta_i + \varepsilon_i, \quad (2.1)$$

where $news_i = 1$ [$news_i = 0$] indicates that the disaster was covered [was not covered] in the news. The vector θ_i contains disaster specific variables, such as *killed* and *affected* and fixed effects for disaster type, country, year, etc. Relief is provided if $relief_i^*$ is above a threshold value,

$$relief_i = \begin{cases} 1 & \text{if } relief_i^* > 0 \\ 0 & \text{if } relief_i^* \leq 0 \end{cases} \quad (2.2)$$

where $relief_i = 1$ [$relief_i = 0$] is the event that OFDA provided [did not provide] disaster relief to disaster i . We will test the hypothesis that news coverage has a positive effect on the relief decision, $\alpha_1 > 0$.

Similarly, the latent variable $news_i^*$ (newsworthiness) describes the benefits of covering disaster i from the TV network's perspective,

$$news_i^* = \beta_1 news_pressure_i + \beta_2 olympics_i + \beta' \theta_i + \omega_i. \quad (2.3)$$

This latent variable determines the news decision according to

$$news_i = \begin{cases} 1 & \text{if } news_i^* > 0 \\ 0 & \text{if } news_i^* \leq 0 \end{cases} . \quad (2.4)$$

Our hypothesis here is that disasters are less likely to be covered when there is a great deal of other breaking news available, as measured by *news pressure* and *Olympics*, that is $\beta_1 < 0$ and $\beta_2 < 0$.

The basic econometric problem is that newsworthiness and reliefworthiness are both increasing in the severity of the disaster. There are many facets of the severity of disasters that we cannot observe, for example, how severe the situation is for those affected (but not killed). This unobserved severity affects both news coverage and the provision of relief. As mentioned earlier, *news* and *relief* may also be correlated because both are driven by the salience of the disaster to the American public. Consequently, there is little hope in identifying the causal effect of *news* on *relief* from a regression of the latter on the former.

To determine whether *news* has a causal effect on *relief*, we instead use the instrumental variables *news pressure* and *Olympics*. Assuming a linear probability model, and that

$$\begin{aligned} E[\varepsilon \mid news\ pressure, olympics, \theta] &= \\ E[\omega \mid news\ pressure, olympics, \theta] &= 0, \end{aligned}$$

the reduced form equations are

$$\begin{aligned} E[relief \mid news\ pressure, olympics, \theta] & \quad (2.5) \\ = \alpha_1 (\beta_1 news\ pressure + \beta_2 olympics) + (\alpha + \beta)' \theta, \end{aligned}$$

$$E[news \mid news\ pressure, olympics, \theta] \quad (2.6)$$

$$= \beta_1 news\ pressure + \beta_2 olympics + \beta' \theta. \quad (2.7)$$

Under the above assumptions, the model is identified and the parameters may be estimated using Two Stage Least Squares.

The key identifying assumption is that *news pressure* and *Olympics* are uncorrelated with the unobserved severity of disasters, ε_i , conditional on the variables in θ_i . There are seasonal patterns in the severity of disasters, such as storms and floods,

and also seasonal patterns in *Olympics* and *news pressure* (with the typical summer news droughts). For this reason, we include month dummy variables. There is also a yearly trend in *news pressure* and *relief*, so we include year dummy-variables. Controlling for year and month effects, we see no a priori reason why the severity of natural disasters in foreign countries should be correlated with our measures of the availability of newsworthy material. We will include further controls in the regressions, but only to reduce the residual variance. Additional concerns regarding identification will be addressed in the robustness section.

3.2 How the availability of other news affect disaster news and relief

We first examine how the pressure for network news time affects news coverage of, and relief to, disasters. Table 4 shows the results from estimating the linear probability models specified in equations (2.5) and (2.6). All regressions include country, year, disaster type, month and year fixed effects and report heteroscedastic robust standard errors.

Higher *news pressure* significantly reduces both the probability that the networks cover a disaster and the probability that the disaster receives relief. This can be seen in the baseline specifications of columns I and IV. The implied effects are that 10 additional minutes spent on the first three news segments decreases the probability of a disaster is being covered in the news by 16 percentage points, and the probability of the disaster receiving relief by 12 percentage points. Recall that around 10 percent of all disasters are covered in the news and that 20 percent receive relief, so the effects are sizeable. Moreover, *Olympics* is significantly negatively correlated with *news* and *relief*. The estimated coefficients imply that a disaster occurring during the Olympics is 5 percent less likely to be in the news and 6 percent less likely to receive relief, on average.¹³

Controlling for the severity of the disaster does not significantly change the estimated coefficients on *news pressure* and *Olympics*. Columns II and V control for the log number of killed and affected. This has the only effect of reducing the precision of the estimates, since the sample size is reduced by 44 percent. In Columns III and VI, we impute the missing values to the average for each type of disaster. Since we also include fixed effects for the interaction between missing data

¹³ To compute the average effect, the coefficients are multiplied by 0.5, which is the average value of *olympics* for days during the Olympic Games.

and the type of disaster,¹⁴ the value at which killed and affected are imputed is of no importance for the estimated coefficients on *news pressure* and *Olympics*.

Disaster relief is equally responsive to the number of killed and affected, while news coverage responds much more to the number of killed. The estimates imply that as the number of killed increases by a factor of ten, the probability of receiving relief and news coverage both increases by about ten percentage points. When the increases in the number of affected is tenfold, the chance of receiving relief increases by around ten percent, but the probability of being covered in the news only increases by three percent.

Note that we may create an endogeneity problem by including the number of killed and affected in the regression. If disaster relief is effective, in the sense of reducing the number of killed and affected, these variables are endogenous to relief. Furthermore, sample selection is likely to be based on the dependent variable, *relief*, causing endogeneity problems. Relief work often entails data collection and USAID is one of the main data providers.

As we add more controls, the residual variance is reduced – R^2 is almost doubled. Yet, the estimated coefficients on *news pressure* and *Olympics* are hardly affected because these variables are uncorrelated with the controls, in particular with *killed* and *affected*. A regression of (the log of) *killed* and *affected*, respectively, on *news pressure* and *Olympics* confirms that there is no significant relationship between these two sets of variables, controlling for year, month, country and disaster type fixed-effects, see Table 5.

3.3 How news affects disaster relief

We now examine what are the implications of the above estimates regarding the effect of news on relief. Table 6 contains the results from regressions analyzing the relation between *relief* and *news*. The first three columns show the results of OLS regressions of *relief* on *news*, using the same specifications as the first three columns of Table 4. The first column shows that being covered in the *news* is associated with a 29 percent increase in the probability of receiving relief. The coefficient on *news* drops significantly, from 29 to 13-15 percent, when we add log *killed* and log *affected* in columns II and III, because *relief* and *news* are both positively correlated with

¹⁴ Indicator variables for: Earthquake and data on killed exists, Earthquake and data on killed missing, Earthquake and data on affected exists, Earthquake and data on affected missing, Volcano and data on killed exists, etc.

killed and *affected*.

There are strong reasons to believe that the effect of news is heterogenous across disasters. For some disasters, news coverage has little effect. For example, the recent Tsunami in Thailand was certain to receive both relief and news coverage. Other disasters are certain to neither receive relief nor news coverage. This is illustrated in Figure 6. The x -axis contains the predicted probability of a disaster being in the news, based on the number of killed and affected, disaster type, year, month and country. The solid diamonds show the share of disasters in each decile covered in the news, while the crosses show the share of disasters receiving relief. For example, of the disasters that have predicted probabilities of being in the news above 90 percent, 80 percent received OFDA relief. In contrast, only 10 percent of the disasters received relief when their predicted probability of being in the news was below 10 percent.

We will argue that the effect of *news* on *relief* is greater for disasters that are marginal in the news decision. The reason is that these disasters are also more likely to be marginal in the *relief* decision. To test this, we include the interaction between *news* and the absolute distance of the predicted probability of the disaster being in the *news* from 0.5 in the regression of *relief* on *news*. The results are shown in Column IV. The estimated coefficient on news is 23 percent when the predicted probability of being in the news is 0.5. When the estimated probability of being in the news is 1 or 0, the partial correlation is zero ($0.23 - 0.5 * .48$). Column V displays the results from a probit-estimation of this model. These effects are estimated using coarse measures of whether a disaster is marginal in the news decision. The effect of *news* on *relief* could be substantially higher in the subgroup of disasters that were truly marginal in the news decision.

As discussed earlier, the above correlations do not measure the effect of *news* on *relief*. What we learn is that the overall average effect of *news* on *relief* is unlikely to be larger than 13 percent, since the bias through unobserved severity of disasters is positive. However, the effect can be substantially higher for the subset of disasters which are close to marginal in the news decision.

The last three columns report the IV estimates. The estimates of α_1 are large and significant. Publishing a story on a disaster will increase the probability of subsequent relief by around 68 percentage points, based on the estimates from a specification in column VII. These estimates are much larger than the OLS estimates. A likely reason is that the IV-estimates measure the average effect of *news* on *relief* in the subgroup of disasters that are marginal in the news decision, in the sense of

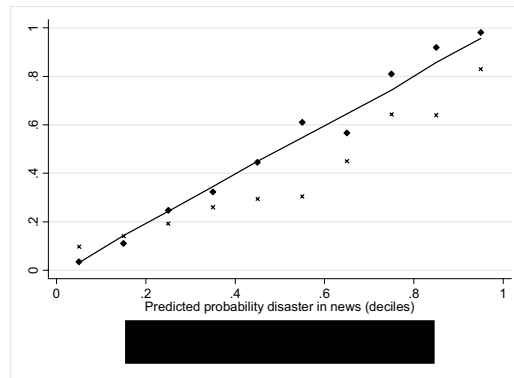


Figure 2.6: Predicted probability of disaster news and actual shares of disasters receiving relief

their receiving news coverage if and only if there is little other news around; see for example Björklund and Moffit (1987), Heckman and Robb (1985) and Imbens and Angrist (1994).

3.4 Robustness

We now discuss a number of potential identification problems. The results of this robustness analysis are shown in Table 7. Horizontally, the table contains results for the reduced form estimates with *news* and *relief* as dependent variables, as well as the resulting IV-estimates of the effect of *news* on *relief*. The first column displays the benchmark specifications corresponding to Column I and IV of Table 4 and Column VI of Table 6. The following columns contain other specifications which will now be discussed.

Many of the endogeneity issues are related to the instrument *news pressure*. On a priori grounds, it is easily argued that the dates of the Olympic Games are exogenous with respect to disaster relief and news coverage, controlling for month effects. One general indication that *news pressure* is also exogenous is that the over-identifying restrictions are not rejected in any specification in Tables 6 and 7. In other words, the IV-estimates using *news pressure* only as an instrument produces a similar coefficient estimate as the IV-estimates instrumenting with *Olympics* only.

We will start by testing our assumption that *news pressure* is uncorrelated with the error in the disaster news equation, ω . Ideally, we would like to measure what *news pressure* would have been, had there been no disaster news. The problem is that on some days there is disaster news and we have to consider how this affects

our instrument. If news about a disaster is placed among the top three stories, this would generate a positive bias (towards zero) in the coefficient β_1 . If news about the disaster is placed outside the top three, then it might be the case that less time is devoted to the top three segments, inducing a negative bias in β_1 .

We construct two alternative measures of the pressure on news time to investigate the potential size of this bias. Recall that *news pressure* is the unweighted average of *daily news pressure* for the 40 days following the disaster. First, we compute *news pressure* as the average during the 40 days after the disaster, but remove all days when any disaster story was aired. This has a minimal impact on the estimated coefficients, see Column II. Next, to gauge the maximum size of the bias, we computed a new measure of *news pressure* that was intentionally biased in the most extreme way. For every news broadcast, we increased the time devoted to the top three news segments (*daily news pressure*) by the time devoted to disaster stories. This corresponds to the extreme assumption that all disaster news was placed outside the top three segments and only took time from these segments. In reality, the news time freed up by not airing the disaster news would be partially allocated to news segments outside the top three. As shown in Column III, the resulting bias in the estimated coefficient on *news pressure* is modest, it changes from -0.016 to -0.013. The likely reason is that we average over 40 days, and only introducing bias in the few days when disasters were covered has little impact. Most (85 %) of the disasters that are in the news, are only covered in one day.

Columns IV and V check whether it is important that we use the 40-day average for *news pressure*. Here, we instead measure *news pressure* as an average putting higher weight on days closer to the disaster. More precisely, Column IV uses the unweighted 20-day average, and Column V uses the empirical distribution of news stories as a function of the distance in days to the disaster for weighting, see Figure 2.2. This produces minor changes. The reason why we use the 40-day average in most specifications is that it is not sensitive to the type of bias described in the previous paragraph.

Next, we add a number of controls in Column VI. We include the imputed log *Killed* and the imputed log *Affected*, dummy variables for the interaction of disaster type and missing data as discussed in Section 3.2. To account for non-linear effects, we also include two sets of dummy variables indicating whether *Killed* and *Affected* lie in the percentile regions 0th-25th, 25th-50th, 50th -75th and the 75th-95th percentiles, respectively (the omitted category is killed above the 95th percentile). In case there is seasonal variations within months, we now include

week-fixed effects. Next, the U.S. may be more willing to provide support to allies and there may be changes in U.S. relations to countries over time, which are not captured by the country-fixed effects. To control for this, we include a variable indicating whether the U.S. has any formal alliance with the country in question.¹⁵ For example, Iran was a formal ally of the U.S. until 1979, but not thereafter. In this specification, the coefficient on *news pressure* falls (insignificantly) in the relief-regression and hence, in the IV-regression. The coefficient on being a U.S. ally (not reported) is not significant in the news coverage or the relief decision, controlling for country fixed effects.

The next two columns report the results from regressions on subsamples. The first subsample only includes disasters where the outbreak is typically well defined: earthquakes, volcanos, fires, landslides, floods and storms. As is evident from Column VII, the results only differ marginally in this subsample.

The other subsample addresses another concern regarding the instrument *news pressure*, namely that the relief decisions are directly affected by the events causing high *news pressure*. For example, an Ambassador in Nicaragua may be directly affected by the 9/11 attack not to declare a concurrent storm in Nicaragua a disaster. However, it seems unlikely that U.S. Ambassadors are inclined to declare a natural disaster because nothing interesting is happening on the Network News, i.e. when the *news pressure* is exceptionally low. For this reason, we remove all observations when the *news pressure* was in the highest 1/3 that year. The remaining observations contain situations where the *news pressure* was medium to low. The coefficient on news pressure now identifies effects because marginally newsworthy disasters, which would typically not be on TV, are shifted into the Network News when the *news pressure* is low. Column VIII shows the results in this subsample. The estimated effects of our instruments on *news* and *relief* are similar or higher. However, since this specification explicitly reduces both the sample size and the sample variation in *news pressure*, the standard errors are much larger and the estimated effects of *Olympics* on *news* and *news pressure* on *relief* are not significant. The IV-estimate of the effect of news on relief is not affected to any considerable extent.

The final column in the table shows the results from probit estimations. For comparison with the OLS-estimates, the coefficients are reported as the estimated change in probability for an infinitesimal change in each independent variable, evaluated at the sample mean. The change in estimation procedure has little effect on

¹⁵ The Correlates of War Formal Interstate Alliance Data Set, v3.03.

the estimated coefficients and standard errors.

A final remark concerns the interpretation of the estimated coefficient on *news*, given that we only consider Television Network News and ignore other mass media. We focus on TV news since most people cite TV as their main source of national and international news.¹⁶ Implicitly, we assume that the U.S. Ambassadors declaring the disasters, or their principals in Washington D.C., care about the image of disaster relief among the general public.

In general, if other news sources are important in affecting the relief decisions, then we must re-interpret our results. Suppose, for example, that coverage in the New York Times has an independent effect on the relief decision. If disaster coverage in the Television Network News and the New York Times is correlated, then the OLS estimates of α_1 do not only include the policy effect of the publication of a network news story. It also includes the effect of a New York Times publication multiplied by the increased probability of the disaster being covered in the New York Times which is implied by TV coverage. Similarly, to the extent that coverage in the New York Times is correlated with *news pressure* and *Olympics*, our instrumental variables estimates will also include the effect through the New York Times.

To conclude, there are strong a priori reasons to believe that the dates of the *Olympics* are exogenous with respect to the characteristics of disasters, and we argue that *news pressure* is also exogenous. Table 5 shows that the instruments are not correlated with the measured severity of disasters in our sample. For this reason, the estimated coefficients of interest are unaffected by accounting for nonlinearities in the effect of killed and affected, or other plausible covariates, see Column VI of Table 7. Column VII in the same table shows that the estimated effects are also very similar in the subsample of disasters where the strike dates are better defined. Regarding the exogeneity of *news pressure*, the overidentification tests show that instrumenting with *news pressure* and *Olympics* yields similar results. In Columns II and III, we show that the endogeneity of *news pressure* with respect to disaster news is not important. In addition, we have shown that the 40-day average assumption is not important. The events causing very high *news pressure* do not seem to directly affect the disaster declarations, since the coefficient estimates remain unchanged when only using observations where news pressure is medium to low.

¹⁶ 82 percent in a Survey conducted by the PEW Research Center in January 2002.

4 Discussion and conclusions

Given the enormous humanitarian stakes, it is essential that disaster relief is provided to those in most need. Still, we show that U.S. disaster relief depends on the availability of other newsworthy material at the time of the disaster, which is obviously unrelated to need. We argue that the only plausible explanation is that relief decisions are driven by news coverage of disasters and that this news coverage is crowded out by other newsworthy material.

We find natural disasters in developing countries to be more likely to receive relief if they occur when the pressure for news time in the U.S. network news broadcasts is low. Quantitatively, disasters are on average around eight percent more likely to receive relief if they occur when *news pressure* takes on its highest values than when taking on its lowest, and five percent less likely to receive relief during the Olympics than at other times. Using another metric, to have the same chance of receiving relief, the disaster occurring during the highest *news pressure* must have six times as many casualties as a disaster occurring when *news pressure* is at its lowest, all else equal.¹⁷ Similarly, a disaster occurring during the Olympics must have three times as many casualties as a disaster on an ordinary day to have the same chance of receiving relief.

The impact of news on disasters appears to vary across disasters. We find that, on average, news coverage is not likely to increase the probability of providing relief by more than around 15 percent. However, for disasters that are marginally newsworthy, in the sense of being covered if and only if there is little other news available, the effect is much larger, around 70 percent. We argue that this is due to the fact that disasters marginal in the news decision are also marginal in the relief decision. This is reasonable and consistent with views expressed by policy makers. Some disasters, like the recent Tsunami in Thailand, are certain to receive both relief and news coverage, while others will receive neither relief nor news coverage,

¹⁷ The specification in Column VI of Table 5 includes estimates on how the probability of receiving relief depends both on the news pressure and the number of killed. The equation we solve is

$$0.0442 \ln(killed_1) - 0.0078 * news\ pressure_1 = 0.0442 \ln(killed_2) - 0.0078 * news\ pressure_2,$$

where *news pressure*₁ is the sample minimum (4.42) and *news pressure*₂ is the sample maximum (14.19). This implies that

$$\frac{killed_1}{killed_2} = \exp\left(\frac{0.0078 * (14.19 - 4.42)}{0.0442}\right) = 5.6.$$

irrespective of the availability of other breaking news.

Some types of disasters are less likely to receive relief because of the network news effect. Sen (1982) argues that media would increase government relief to famines at the expense of relief to endemic hunger. The reason is that famines are more dramatic and therefore newsworthy events that receive coverage in the media. However, among the set of natural disasters, famines are among the least newsworthy. In the words of Andrew Natsios, administrator of USAID, "In a war or famine, the most common types of slow-onset disasters, there are fewer spectacular events to report on than there are in earthquake or volcanic disasters." (Natsios (1995)).

Table 9 displays the estimated newsworthiness of different types of disaster. While around 30 percent of the earthquakes and volcanic disasters are covered by the networks, less than 5 percent of the epidemics, droughts and food shortages are covered, see the first column. This is not because earthquakes and volcanos are more severe in terms of the number of killed or affected. The next column contains the estimated disaster type fixed effects from a regression including log *Killed*, log *Affected*, and fixed effects for country, year and month. This only accentuates the differences. In the last column, we have computed the casualties ratio that would make media coverage equally likely, all else equal (controlling for the same factors as in the fixed effects regression). For example, for every person that dies in a volcano disaster, 39 817 people must die of food shortage to receive the same estimated media coverage. The conclusion is that media induces additional relief to volcano and earthquake victims, at the expense of victims of epidemics, droughts, cold waves and food shortages.

Network news also induces a relief bias against Africa, Asia and the Pacific, see Table 10. While the TV networks cover more than 15 percent of the disasters in Europe and South and Central America, they cover less than 5 percent of the disasters in Africa and the Pacific. Asian disasters are more in the news than African ones because they are of more newsworthy types. In particular, Africa has many droughts and food shortages relative to Asia. There is no significant difference in news coverage after controlling for disaster type, log *killed* and log *affected*, month and year. The remaining differences between Africa, Asia and the Pacific on the one hand, and Europe and South and Central America on the other, are huge. The estimates suggest that it requires 46 times as many killed in an African disaster to achieve the same probability of media coverage as for a disaster in Europe. We conclude that media coverage induces additional U.S. relief to victims in Europe and the American continent, at the expense of victims elsewhere.

The role of network news has changed over time. Figure 10 plots the year-fixed effects from the *news* equation. We see that there is an increasing trend in the probability of coverage. One potential explanation is what political scientists have termed the "CNN effect" (for an overview see Robinnson (1999) and Gilboa (2005)). According to this theory media has come to play an increasing role in U.S. foreign policy. This has partly been driven by innovations in communication technologies, which has substantially reduced the costs of broadcasting from remote areas.

Our findings have important implications for the literature on media and politics. First, as previously mentioned, we quantitatively document the relationship between the publication of news stories and government policies. Second, our measures of available newsworthy material can be used to identify the effects of media stories on other outcome variables. It is easy to think of examples: the effect of news publication of earnings announcements on subsequent stock return, or the effect of the publication of unemployment or inflation reports on inflation expectations.

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5 Appendix 1

The section derives two simple models illustrating how media coverage could affect relief policy. The public action model assumes there to be a group of voters who care about disaster relief, but who are initially uninformed about the occurrence of specific natural disasters. When media informs them about a natural disaster, they lobby their political representative to work for relief being provided. In the second model, voter support depends on disaster relief efforts reported in the news. When a policy maker observes that a disaster is covered in the news, he or she realizes that it is more likely that relief efforts will also be covered. Hence, there is an increase in the incentives to provide relief.

Both these models have the implication that disasters that are in the news are more likely to receive relief. This is the hypothesis that we test empirically. We do not attempt to empirically distinguish between the models.

5.1 Public action

The timing of the model is the following. First, a disaster of severity θ occurs. The media chooses whether to cover the disaster. Let the indicator variable $news \in \{0, 1\}$ equal 1 if this is done by the media. Based solely on the information provided by the media, voters may lobby for relief to be provided. Next, the policy makers take the decision to provide relief. The variable $relief \in \{0, 1\}$ indicates whether relief is given. Finally, voters cast their votes based on the policy action.

We assume that the utility gain from disaster relief to be increasing in the severity of the disasters. Let $u(relief, \theta)$ be the utility of disaster victims less the cost of relief. The gain from relief is

$$u(relief = 1, \theta) - u(relief = 0, \theta) = relief u(\theta),$$

where $u'(\theta) > 0$. Thus, the larger the disaster, the larger the marginal utility of aid.

U.S. voters are altruistic and care about the welfare of the disaster victims. The expectation of the net benefit from relief is

$$E^V [\text{relief } u(\theta) \mid \text{news}] = \begin{cases} \text{relief } u(\theta) & \text{if } \text{news} = 1 \\ \bar{u} & \text{if } \text{news} = 0. \end{cases},$$

where \bar{u} is the expected net benefit from relief, not knowing the severity of the disaster or whether relief was provided, $\bar{u} = E^V [\text{relief } u(\theta)]$.

After having observed a disaster where $u(\theta) > 0$, an action group approaches the incumbent politician. There are a number of actions the group could take to pressure the politicians to work for relief being provided; they could demonstrate, or explain that their votes depend on the relief decision. We simply model this as offering to pay campaign contributions c if relief is provided.

In the election, a voter i will vote to re-elect the incumbent if

$$c + \beta_i + \eta \geq 0,$$

The term β_i captures voter preferences on all other issues, which we treat as exogenous, and η captures a common popularity shock. Both β_i and η are uniformly distributed on the interval from $-\frac{1}{2}$ to $\frac{1}{2}$. The term c is the effect of the campaign contributions on election outcome. The probability of the incumbent being re-elected is therefore

$$P = \frac{1}{2} + \text{news} \cdot \text{relief} \cdot c,$$

provided that the parameters are such that the above expression lies between zero and one.

We assume that the Ambassador cares about the disaster victims, but also puts a weight λ on voter support for the incumbent, P . This could be because they care about the funding of the relief program, and this is increasing in its pay-off to the incumbent. It could also be because their future career depends on how well they manage the relief program in the incumbent's interest. The Ambassador faces an opportunity cost $-\varepsilon$ of declaring the disaster. He or she declares a disaster, $\text{relief} = 1$, if

$$u(\theta) + \lambda \text{news} \cdot c + \varepsilon > 0.$$

The level of campaign contributions can be endogenized.¹⁸ Then, the Ambassador declares a disaster if

$$(1 + \lambda^2 news) u(\theta) + \varepsilon > 0. \quad (2.8)$$

Hence, the probability that relief is provided is higher for disasters that are in the news.

5.2 Voting and information

The timing of this model is the following. First a disaster of severity θ occurs. The media chooses whether to cover the disaster. Let the indicator variable $news \in \{0, 1\}$ equal 1 if this is done by the media. Next, the Ambassador chooses whether to provide relief. The variable $relief \in \{0, 1\}$ indicates whether relief is given. Then, the media chooses whether to cover the disaster again, captured by the indicator variable $followup_news \in \{0, 1\}$. If it does so, it also reports on whether relief was given. Finally, voters cast their ballots based on the information provided by the media.

The gain from relief is modelled as before. U.S. voters are once more altruistic and care about the welfare of the disaster victims. However, their expectation of the benefit from relief is now

$$E^V [relief u(\theta)] = \begin{cases} relief u(\theta) & \text{if } followup_news = 1 \\ p(\theta, news = 1) u(\theta) & \text{if } news = 1 \text{ and } followup_news = 0 \\ E^V [p(\theta, news = 0) u(\theta)] & \text{if } news = 0 \text{ and } followup_news = 0. \end{cases} .$$

¹⁸ Assuming that ε is uniformly distributed between zero and one, the probability of giving relief equals

$$u(\theta) + \lambda c news$$

Assume that the cost for the action group to collect funds is $\frac{1}{2}c^2$. Given this, the action group will offer the policy maker the contribution which solves,

$$\max_c (u(\theta) + \lambda c news) u(\theta) - \frac{1}{2}c^2,$$

which is

$$c = \lambda news u(\theta).$$

So the probability of providing disaster relief is

$$(1 + \lambda^2 news) u(\theta).$$

The function $p(\theta, news = 1)$ is the voters' assessed probability that disaster relief is provided, given that media has reported θ . Analogously, $p(\theta, news = 0)$ is the assessed probability if the media did not report on the disaster.

A voter i will vote to re-elect the incumbent politician if his or her expected utility is larger than some reservation utility

$$E^V [relief u(\theta)] + \beta_i + \eta \geq 0,$$

and the probability that the incumbent is re-elected is

$$P(relief) = \frac{1}{2} + E[relief u(\theta)].$$

The Ambassador once more cares about the effect of the disaster funds, but also puts a weight λ on voter support. He or she declares a disaster if

$$u(\theta) + \lambda E \left[\frac{P(relief)}{\Delta relief} \right] + \varepsilon > 0,$$

or equivalently,

$$(1 + \lambda\rho) u(\theta) + \varepsilon > 0, \tag{2.9}$$

where ρ is the Ambassador's perceived probability that the disaster is covered in the media after the relief decision. Votes are only affected by the relief decision if the relief efforts are covered by the media, which happens with probability ρ .

We now discuss this probability of relief news coverage. The media will initially cover the disaster if it is sufficiently newsworthy and if little other news is around. Formally

$$news = 1, \text{ if } \theta + \theta_m + \varepsilon_n \geq 0,$$

where θ is the severity of the disaster, θ_m is the availability of other newsworthy material, and ε_n are other features of newsworthiness such as how dramatic event the event is and if it provides good photage. Similarly, the media will cover the disaster relief,

$$followup_news = 1, \text{ if } \theta + \theta_m + \varepsilon_{n2} \geq 0.$$

A key feature is that the newsworthiness parameters, ε_n and ε_{n2} are positively correlated. This positive correlation could arise because of the fixed cost in the news technology (e.g. sending reporters), because of disaster fixed characteristics (e.g. good photage), or because an initial story builds up viewer interest.

This implies that the probability of media covering the relief is higher if media covered the disaster initially. Let this probability be

$$\rho(\text{news}, \theta, \theta_m) = \Pr(\text{followup_news} = 1 \mid \text{news}, \theta, \theta_m).$$

Then

$$\rho(\text{news} = 1, \theta, \theta_m) > \rho(\text{news} = 0, \theta, \theta_m),$$

because of the correlation between ε_n and ε_{n2} .

In other words, an Ambassador observing that a disaster is covered by the media realizes that this makes it more likely that disaster relief efforts are also covered. Hence, the incentives to provide relief are stronger.

Table 1: Summary Statistics for Disasters

Disaster type	Number of disasters	Share of disasters	Killed per disaster	Affected per disaster	Share receiving OFDA relief
Flood	1 675	0.32	170	1 724 851	0.22
Storm	1 175	0.23	646	601 490	0.17
Epidemic	737	0.14	249	27 528	0.12
Earthquake	559	0.11	1 522	173 015	0.21
Drought	326	0.06	18 657	5 740 623	0.30
Landslide	310	0.06	84	38 789	0.06
Fire	129	0.02	19	69 552	0.13
Cold wave	114	0.02	103	46 656	0.01
Volcano	102	0.02	853	39 008	0.27
Infestation	47	0.01	na	1 100	0.68
Food shortage	38	0.01	4 293	734 630	0.13
Total	5 212	1.00	590	1 166 505	0.19

[4]

Table 2: Two largest *daily news pressure* dates and main story, by year

Year	Date	Main News Story
2003	14 Aug	New York City Blackout
	22 Mar	Invasion of Iraq: Day 3
2002	11 Sep	9/11 Commemoration
	24 Oct	Sniper Shooting in Washington: Arrest of Suspects
2001	13 Sep	9/11 Attack on America: Day 3
	12 Sep	9/11 Attack on America: Day 2
2000	26 Nov	Gore vs. Bush: Florida Recount - Certification by Katherine Harris
	8 Dec	Gore vs. Bush: Florida Recount - Supreme Court Ruling
1999	1 Apr	Kosovo Crisis: U.S. Soldiers Captured
	18 Jul	Crash of Plane Carrying John F. Kennedy, Junior
1998	16 Dec	U.S. Missile Attack on Iraq
	18 Dec	Clinton Impeachment
1997	23 Dec	Oklahoma City Bombing: Trial
	31 Aug	Princess Diana's Death
1996	18 Jul	TWA Flight 800 Explosion
	27 Jul	Olympic Games Bombing in Atlanta
1995	3 Oct	O.J. Simpson Trial: The Verdict
	22 Apr	Oklahoma City Bombing
1994	17 Jan	California Earthquake
	18 Jun	O.J. Simpson Arrested
1993	17 Jan	U.S. Missile Attack on Iraq
	20 Apr	Waco, Texas: Cult Standoff Ends in Fire
1992	16 Jul	Perot Quits 1992 Presidential Campaign
	1 May	Los Angeles Riots
1991	27 Feb	Gulf War: President Bush Declares Kuwait Liberated
	17 Jan	Gulf War: Operation Desert Storm Launched
1990	4 Aug	Iraq Invasion of Kuwait: Day 4
	8 Aug	Iraq Invasion of Kuwait: Mobilisation of U.S. Troops
1989	9 Mar	Senate Rejection of Tower Appointment to Secretary of Defense
	23 Dec	Romania Revolution
1988	22 Dec	Pan Am Plane Crash
	14 Dec	Arafat Condemns Terrorism and Accept Israel's Right to Exist
1987	26 Feb	Iran Arms Scandal: Tower Commission Report
	18 May	USS Stark Attack in Persian Gulf
1986	29 Jan	Challenger Explosion
	15 Apr	U.S. Attack on Libya
1985	30 Jun	TWA Flight 847 Hijacking: Release of Hostages
	29 Jun	TWA Flight 847 Hijacking: Release of Hostages
1984	12 Jul	Ferraro as Vice President Candidate
	16 Aug	Delorean Verdict
1983	25 Oct	U.S. Invasion of Grenada: Day 1
	3 Sep	USSR Downing of Korean Commercial Flight
1982	4 Aug	Israel Invasion of Lebanon
	2 Jan	Poland: Martial Law
1981	30 Mar	Ronald Reagan Assassination Attempt
	13 Dec	Poland: Martial Law Declared by Wojciech Jaruzelski
1980	10 Aug	Hurricane Allen in Texas
	26 Dec	Iran Hostage Crisis: Iran Release Film of Hostages

1979	31 Mar 15 Dec	Three Mile Island Nuclear Accident Iran Hostage Crisis: Departure of Shah from U.S. Announced
1978	19 Nov 6 Aug	Guyana Incident: Sect Mass Suicide Death of Pope Paul VI
1977	14 Jul 11 Aug	New York City Blackout Serial Killer David Berkowitz Arrested
1976	13 Jul 9 Jun	Democratic Convention Jimmy Carter Wins in Primaries
1975	3 Nov 14 May	Nelson Rockefeller Decides Not to Run for Vice President Mayaguez Incident: U.S. Attacks
1974	1 Mar 21 Jul	Watergate Indictments Announced Turkey Invades Cyprus
1973	12 Feb 24 Jan	Vietnam War: U.S. Prisoners of War Released Vietnam War: Cease-Fire Agreement Reached
1972	9 Jan 28 May	Howard Hughes Telephone Conference Nixon Visit in USSR: SALT I signed
1971	16 Jul 16 Aug	Nixon Announces Trip to China Nixon Suspends Convertibility from Dollars to Gold
1970	28 Sep 7 Sep	Gamal Abdel Nasser Dead Dawson's Field Hijackings: Blow Up of Planes
1969	15 Oct 28 Mar	Vietnam Anti-War Demonstration (Moratorium) Eisenhower Dead
1968	22 Aug 1 Nov	USSR Invades Czechoslovakia: Day 2 October Surprise: Vietnam Bombing Halt

Note: Ordered by *daily newspressure*

Table 3. Summary statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
<i>relief</i>	5 212	0.19	0.39	0	1
<i>news</i>	5 212	0.12	0.32	0	1
<i>killed</i>	3 714	590	9 143	1	300 000
<i>affected</i>	4 004	1 092 508	9 858 292	1	300 000 000
<i>news pressure</i>	5 212	7.73	1.22	4.56	14.32
<i>Olympics</i>	5 212	0.02	0.09	0	0.77
<i>US ally</i>	5 212	0.32	0.47	0	1

Table 4: Effect of the pressure for news time on disaster *News* and *Relief*

	Dependent variable: <i>News</i>			Dependent variable: <i>Relief</i>		
	I	II	III	IV	V	VI
<i>News Pressure</i>	-0.0163 (0.0041)***	-0.0172 (0.0056)***	-0.0143 (0.0037)***	-0.0119 (0.0045)***	-0.0094 (0.0058)	-0.0078 (0.0040)**
<i>Olympics</i>	-0.1080 (0.0470)**	-0.0849 (0.0628)	-0.1111 (0.0413)***	-0.1232 (0.0521)**	-0.1071 (0.0763)	-0.1098 (0.0479)**
<i>log Killed</i>		0.0604 (0.0040)***			0.0582 (0.0044)***	
<i>log Affected</i>		0.0121 (0.0024)***			0.0376 (0.0024)***	
<i>imputed Log Killed</i>			0.0495 (0.0034)***			0.0442 (0.0037)***
<i>imputed Log Affected</i>			0.0148 (0.0020)***			0.0394 (0.0020)***
Observations	5212	2926	5212	5212	2926	5212
R-squared	0.1791	0.3625	0.2861	0.1989	0.4115	0.3726

Linear probability OLS regressions. All regressions include year, month, country and disaster type fixed effects. Regressions with imputed values (III and VI) also include fixed effects for the interaction of missing values and disaster type. Robust standard errors in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5. Correlations between instruments and the severity of disasters

	log Killed	log Affected
<i>News Pressure</i>	-0.0182 (0.0258)	-0.0065 (0.0438)
<i>Olympics</i>	-0.0209 (0.3263)	-0.4569 (0.5897)
p-value: F-test of joint insignificance	0.78	0.73
Observations	3714	4004
R-squared	0.2615	0.3571

OLS regressions including year, month, country and disaster type fixed effects. Robust standard errors in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6. Dependent variable: *Relief*

	OLS							
	I	II	III	IV	V	VI	VII	VIII
News	0.2859 (0.0200)***	0.1529 (0.0232)***	0.1293 (0.0178)***	0.2288 (0.0329)*** -0.4819 (0.1062)***	0.2549 (0.0567)*** -0.2921 (0.0851)***	0.8228 (0.2526)***	0.6543 (0.3478)*	0.6746 (0.2544)***
News*abs(Pr(news)>0.5)				0.5378 (0.0942)***	0.2945 (0.0834)***			
abs(Pr(news)>0.5)								
log Killed		0.0489 (0.0046)***					0.0187 (0.0216)	
log Affected		0.0359 (0.0024)***					0.0297 (0.0050)***	
imputed log Killed			0.0378 (0.0038)***	0.0549 (0.0050)***	0.0308 (0.0046)***			0.0107 (0.0132)
imputed log Affected			0.0376 (0.0020)***	0.0444 (0.0023)***	0.0344 (0.0026)***			0.0295 (0.0044)***
F-stat, instruments, 1 st stage						11.1	5.8	11.2
Over-id restrictions, χ^2_{df} (p-value)						0.511(0.47)		0.641(0.42)
Observations	5212	2926	5212	5212	5027	5212	2926	5212
R-squared	0.2435	0.4217	0.3798	0.3857				

All regressions include year, month, country, and disaster type fixed effects. Regressions with imputed values (III and VI) also include fixed effects for the interaction of missing values and disaster type.

Robust standard errors in parentheses:

* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7. Robustness

	Changes in independent variables								
	Reference	II	III	IV	V	VI	VII	VIII	IX
Reduced form regressions. Dependent variable: News									
News Pressure	-0.0163 (0.0041)***	-0.0157 (0.0040)***	-0.0124 (0.0042)***	-0.0133 (0.0033)***	-0.0155 (0.0036)***	-0.0143 (0.0038)***	-0.0193 (0.0052)***	-0.0242 (0.0118)**	-0.0174 (0.0048)***
Olympics	-0.1080 (0.0470)**	-0.1085 (0.0469)**	-0.1114 (0.0470)**	-0.1125 (0.0470)**	-0.1156 (0.0470)**	-0.1090 (0.0460)**	-0.1008 (0.0572)*	-0.1320 (0.0864)	-0.1048 (0.0547)*
Observations	5212	5212	5212	5212	5212	5212	3950	3473	4266
R-squared	0.1791	0.1789	0.1779	0.1789	0.1795	0.2969	0.1862	0.2072	0.2072
F-test (instr.)	11.1	10.5	7.4	11.19	12.3	10.0	8.6	3.4	3.4
Reduced form regressions. Dependent variable: Relief									
News Pressure	-0.0119 (0.0045)***	-0.0116 (0.0045)***	-0.0104 (0.0046)**	-0.0092 (0.0038)**	-0.0085 (0.0041)**	-0.0082 (0.0040)**	-0.0126 (0.0054)**	-0.0125 (0.0142)	-0.0135 (0.0051)***
Olympics	-0.1232 (0.0521)**	-0.1235 (0.0521)**	-0.1250 (0.0520)**	-0.1266 (0.0521)**	-0.1290 (0.0521)**	-0.1182 (0.0515)**	-0.1338 (0.0583)**	-0.1767 (0.0893)**	-0.1426 (0.0705)**
Observations	5212	5212	5212	5212	5212	5212	3950	3473	5209
R-squared	0.1989	0.1989	0.1986	0.1987	0.1985	0.3851	0.1835	0.2271	0.2271
IV-regressions. Dependent variable: Relief									
News	0.8228 (0.2924)***	0.8351 (0.2595)**	0.9391 (0.3225)***	0.8012 (0.2561)***	0.6726 (0.2341)***	0.7124 (0.2637)***	0.7561 (0.2581)***	0.8505 (0.4597)*	0.9454 (0.0406)***
Observations	5212	5212	5212	5212	5212	5212	3910	3446	5209
Over-id test	0.511(0.47)	0.471(0.49)	0.201(0.66)	0.611(0.43)	1.271(0.26)	0.751(0.39)	1.101(0.30)	0.851(0.36)	

Robust standard errors in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. All regressions include year, month, country and disaster-type fixed-effects. Column I reports the results from an OLS regression. In Column II all days with news about disasters have been removed before computing the average *news pressure*. In Column III an extreme bias has been intentionally induced in *news pressure*. In Column IV *news pressure* is the 20-day average of *daily news pressure*, and in Column V it is the average using the weights reported in Figure 2. The regression in Column VI contains controls for whether the country was a US Ally, imputed log Killed and imputed log Affected, dummy variables for the interaction of disaster type and missing data, as well as two sets of dummy variables indicating whether *Killed* and *Affected* lie in the percentile regions 0th-25th, 25th-50th, 50th-75th, 75th-95th percentiles respectively (omitted category is killed above 95th percentile). Column VII contains a sub sample with only earthquakes, floods, fires, landslides, storms and volcano eruptions. Column VIII excludes observations where *News Pressure* was in the highest third each year.

Table 8. Newsworthiness of Disasters, by Disaster Type

	Share in news	(se)	Fixed effects	(se)	Equal coverage casualties ratio*
Volcano	0.29	(0.05)	0.64	(0.09)	1
Earthquake	0.32	(0.02)	0.57	(**)	3
Fire	0.14	(0.03)	0.49	(0.09)	12
Storm	0.14	(0.01)	0.29	(0.03)	336
Flood	0.09	(0.01)	0.23	(0.02)	806
Landslide	0.06	(0.01)	0.20	(0.03)	1 379
Epidemic	0.02	(0.01)	0.18	(0.03)	2 006
Drought	0.03	(0.01)	0.16	(0.07)	2 563
Cold wave	0.06	(0.02)	0.15	(0.07)	3 056
Food shortage	0.03	(0.03)	0.00	(0.10)	39 817

The fixed effects regression includes log *Killed*, log *Affected*, and country, year and month fixed effects.

*To have the same estimated probability of being covered by the Television Network News, a food shortage must have 39 817 times as many casualties as a volcano, all else equal (country, year, month, and number affected).

** Earthquake is the omitted category.

Table 9. Newsworthiness of Disasters, by Continents

	Share in news	(se)	Fixed effects	(se)	Equal coverage casualties ratio*
Europe	0.18	(0.02)	0.25	(**)	1
S. and C. America	0.18	(0.01)	0.18	(0.04)	3
Asia	0.12	(0.01)	0.04	(0.03)	43
Africa	0.03	(0.01)	0.03	(0.04)	46
Pacific	0.03	(0.01)	0.00	(0.04)	84

The fixed effects regression includes log *Killed*, log *Affected*, and disaster type, year and month fixed effects.

*To have the same estimated probability of being covered by the Television Network News, a disaster in the

Pacific must have 84 times as many casualties as one in Europe, all else equal (disaster type, year, month, and number affected).

** Europe is the omitted continent.

Table 10. Newsworthiness of Disasters, by Five-Year period

	Share in news	(se)	Fixed effects	(se)	Equal coverage casualties ratio*
1968-1972	0.14	(0.02)	-0.17	(0.03)	16
1973-1977	0.13	(0.02)	-0.10	(0.03)	5
1978-1982	0.12	(0.02)	-0.14	(0.02)	10
1983-1987	0.06	(0.02)	-0.16	(0.02)	13
1988-1992	0.10	(0.01)	-0.10	(0.02)	5
1993-1997	0.11	(0.01)	-0.10	(0.02)	4
1998-2002	0.13	(0.01)	0.00	(**)	1

The fixed effects regression includes log *Killed*, log *Affected*, and disaster type, country and month fixed effects.

*To have the same estimated probability of being covered by the Television Network News, a disaster in the

1968 must have 16 times as many casualties as one in 2002, all else equal (disaster type, country, month, and number affected).

** 1998-2002 is the omitted period.

Chapter 3

Fiscal Policy and Retirement in the Twentieth Century*

1 Introduction

One of the most pronounced trends in developed economies around the world is the decline in labor force participation among older workers. In the US, for instance, the median retirement age was 78 in 1900. In the year 2000, 12% of the 78 year olds were in the labor force, and the median age of retirement was 62.2.

A major explanation proposed for the decrease in labor force participation among older workers has been the rise in the size and scope of the social security system. Initiated in 1935, the U.S. pension system is now an entitlement program that covers nearly all workers and retirees. In 1950 only 16 percent of those aged 65 or more received pension benefits (OAI), as compared to 91 percent in 1999 (SSA, 2001). Moreover, the system has become increasingly generous. The real average monthly benefit to retired workers rose from \$295 in 1950 to \$804 in 1999 (constant 1999 dollars), an increase of more than 250 percent. On average, the share of social security benefits in total household income of people aged above 65 rose from 22 percent in 1958 to 38 percent in 1998 (SSA, 2000b and Samwick, 2001). Then, at the end of the twentieth century, social security provided more than half the income for 64 percent of the aged households and was the only source of income for 18 percent.

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Did the rise of social security create this tremendous change in retirement behavior? Observations, such as those made above, would suggest that it did. However, economists have not been able to establish this as an undisputable fact. First, the microestimates of the retirement elasticity with respect to social security are notoriously low. Indeed, in reviewing the literature, Krueger and Meyer (2002) conclude that microeconomic studies "tend to find a very modest impact of Social Security [...] on labor supply [...]". Burtless' (1986) contention, based on his own estimate of the retirement elasticity, is that "the main explanation for the rapid decline in employment of older males must lie elsewhere". Second, the trend towards earlier retirement started already at the beginning of the century, before social security was introduced, thus raising the question of whether the drop would have occurred anyway.

Consequently, economists have looked elsewhere for explanations. Costa (1998) and Kopecky (2005) argue that falling prices of leisure goods have made leisure more attractive. The model of Matsuyama (2005) implies that economic development induces elderly to substitute into leisure, since leisure is a luxury good. Ahituv and Zeira (2000) suggest that faster technological progress increases the depreciation of skills, resulting in earlier exit from the labor market. Moreover, Kalemli-Ozcan and Weil (2004) argue that the increase in life expectancy reduces the risk of saving for retirement, allowing earlier labor market exit.

In contrast, this paper argues that it is premature to dismiss social security as an explanation for the secular trend in retirement behavior. In particular, by adequately accounting for changes in life expectancy and fiscal policy over the past century, it is shown that social security could indeed have been a main contributing factor. Moreover, the model is shown to be consistent both with the small contemporary retirement elasticities found in the microeconomic literature, and with the drop in retirement ages prior to the introduction of social security. In particular, the retirement elasticity is shown to be a decreasing and convex function of the replacement rate, with only a small slope at the present level of replacement rates. Furthermore, the early drop in retirement ages can be attributed to the increase in government lending. This resulted in an increase in interest rates – the return to retirement income – and therefore to earlier retirement.

A stylized model of the U.S. economy is developed in order to argue that fiscal policy and social security have been a main driving force in the evolution of retirement over the past century. The model features households that choose consumption, savings, hours worked as well as their age of retirement. Profit maximizing

firms choose inputs of labor and capital. To emphasize the role of fiscal policy, the government is modelled in some detail. In particular, the government provides a public consumption good and transfers, including social security benefits. Government expenditures are financed either through taxes on labor and capital income, or by issuing debt. Social security is modelled as a flat replacement rate on the average earnings in the economy. However, consistent with the U.S. social security system, the rate depends on the age of retirement. This feature is important since it allows for internal solutions to the retirement problem.

The model is calibrated to capture features of the U.S. economy in the year 2000. Government expenditures, government debt and payroll taxes are calibrated to match the data. A general income tax is residually determined to balance the government's budget. Households have productivity profiles and life-expectancies consistent with the data. The utility function is calibrated to capture hours worked during prime-age and a realistic Frisch elasticity. Importantly, the resulting retirement age, which is not calibrated, is broadly consistent with the empirical evidence.

The subsequent experiments keep the parameters fixed, but change government policy and life expectancy as observed in the data. The model does a good job in matching the trend in the average retirement age over the past century. A number of experiments reveal that the rise in the returns to savings and the introduction of social security are the most important factors driving the decline in retirement ages.

The remainder of the paper proceeds as follows. Section 2 describes the empirical evidence on the evolution of retirement behavior during the twentieth century in the United States. Section 3 describes the economic model and section 4 discusses the procedure for calibrating the economy to the U.S. in the year 2000. Section 5 first carries out a steady state analysis using historical data on life expectancy and fiscal policy, including social security. Section 6 offers a discussion of the results in view of the two retirement puzzles. Section 7 offers concluding remarks.

2 Trends in retirement

Retirement is defined as the withdrawal from the labor force by older workers. It is usually, but not always, permanent and often related to the claiming of social security benefits. This section presents evidence of the general trend in retirement in the United States during the twentieth century. Evidence from other countries is also presented suggesting this to be a common trend in most developed economies.

The evolution of retirement over the past century can be documented in a variety

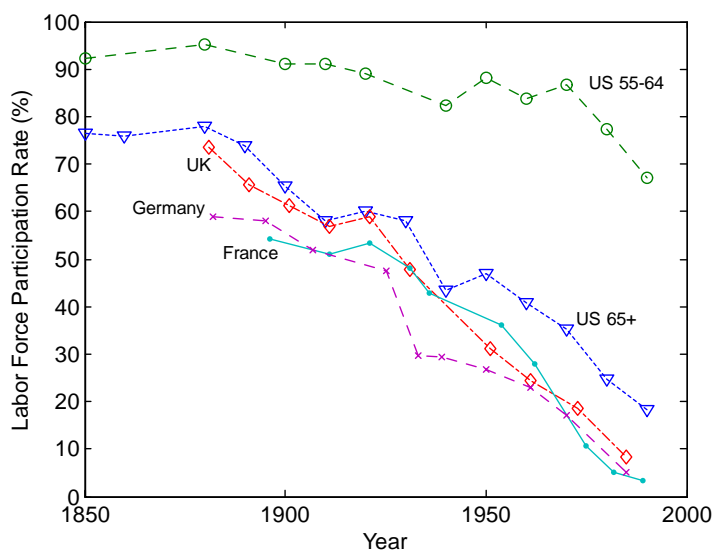


Figure 3.1: Labor Force Participation Rates, Men, 65+, United States, France, Germany, Britain, and 55-64, United States.

of ways. Figure 3.1 shows the labor force participation rates of men aged 65 and above for the period 1850 to 1990 for the United States, Great Britain, France, and Germany, and the labor force participation rates of men aged 55-64 for the United States (Costa (1998)). Notice that the decline occurred simultaneously in all four countries. The labor force participation rate for males aged 55-64 remained roughly constant until 1970, when it started to decline.

Kopecky (2005) estimates male retirement rates for the period 1850-2000 in the United States. Retirement rates are computed as the ratio between the number of men who are retired to the total of all men in the labor force and retired.¹ Figure 3.2 displays the retirement rates by age group and year. The retirement rates increase for all age groups, but most markedly for the groups past the age of 60. Notice that the trend towards earlier retirement accelerates around the year 1900 for age groups past the age of 65. The acceleration occurs after 1970 for those aged 60-64. For those aged 65-69, the retirement rate increases from 12% in 1850 to 71% in 2000. The trend is only interrupted during the two world wars.

The model developed in later sections can be used to make predictions about the age of retirement. Using data from Kopecky (2005), the median retirement age has

¹ Those who never participated in the labor force are not counted, i.e. $\% \text{ retired} = (\% \text{ not in labor-force} - \% \text{ never participating}) / (1 - \% \text{ never participating})$.

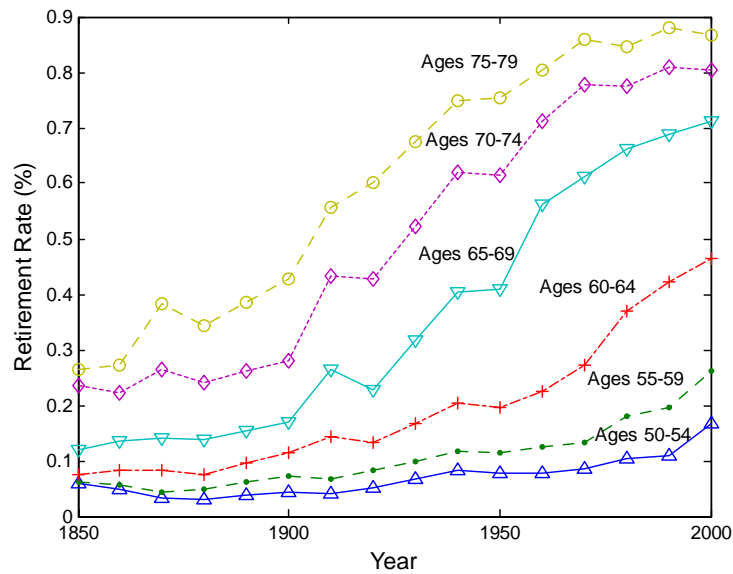


Figure 3.2: Retirement Rates for Men Aged 50 and above by Age Group, 1850-2000, United States

been computed as the age at which half the male population is out of the labor force (see Figure 3.3).² By this measure, the retirement age declined from 79 in 1900 to 73.9 in 1910 and 69.3 in 1940. During WWII, there was nearly no change in the retirement age, while the period between 1950 and 1960 once more experienced a large decline from 69.3 to 65.4. Between 1960 and 1990, the retirement age declined by around one year per decade, and stood at 62.3 in year 2000.

This measure of the retirement age confounds cohort-effects with time-effects. However, more advanced measures which attempt to account for cohort-effects roughly find similar trends for the post-WWII period, although the levels differ somewhat. For instance, Gendell (2001) estimates that the median age of labor force withdrawal declined from 66.9 in 1950 to 62 at the end of the 1990's. Using a related method, Blöndal and Scarpetta (1998) find that the retirement age declined from 66.9 to 63.3 during the same period. Gendell (2001) constructs an alternative measure based on social security benefit claims. This measure shows a sharp decline in the retirement age between 1950 and 1970, from 68.5 to 62.9. After 1970, the declining trend in the retirement age levels off. Gendell (2001) and Blöndal and Scarpetta (1998) also show that the trends have been roughly similar for both men

² A cubic spline is used to compute the exact retirement age.

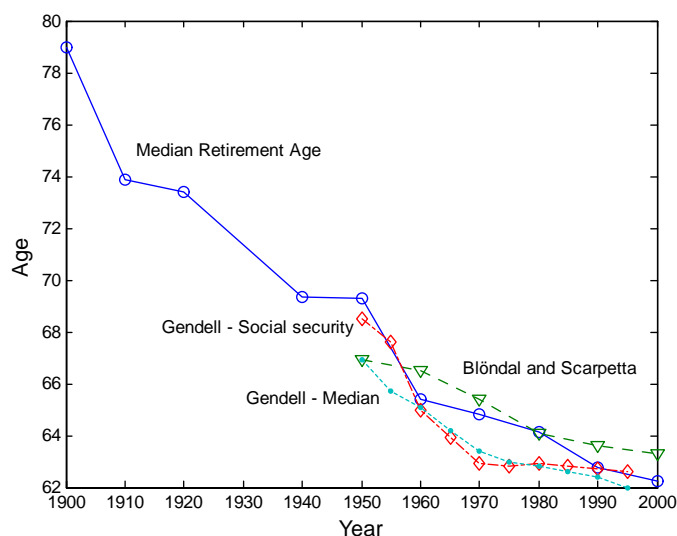


Figure 3.3: The Retirement Age in the United States, Males, 1900-2000.

and women.

The decline in average retirement ages has occurred contemporaneously with the increase in life expectancy. A 65 year old male worker could expect to live another 11 years in 1900, another 12 years in 1940, and another 15 years in 1990 (Burtless (1999)). For women, the increase has been even more pronounced – the corresponding numbers are 12, 13 and 19, respectively. Thus, there is a substantial increase in the expected duration of retirement. Figure 3.4 shows the expected percentage of adult life spent in retirement.³ Thus, a twenty-year old male in 1850 would have expected to live six percent of his adult life in retirement. The corresponding figure in 1990 was nearly thirty.

3 The economic model

This section develops a model to account for the trends in retirement behavior. The model is related to Auerbach and Kotlikoff (1987). However, the model allows for endogenous retirement. Moreover, to gauge the importance of social security, the U.S. social security rules will be modelled in some detail.

³ Data is from Kopecky (2005). The expected length of retirement is computed assuming twenty year-olds to have perfect information about future mortality rates.

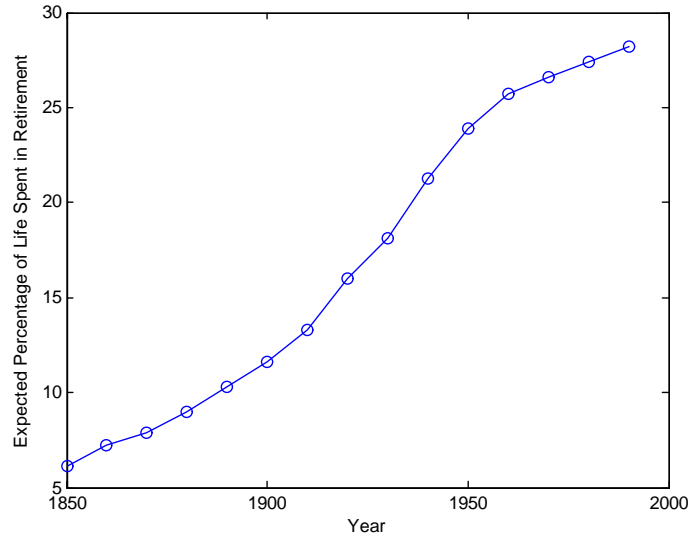


Figure 3.4: Expected share of Adult Life Spent in Retirement (%), United States

3.1 Demographics

The economy is populated by individuals living a maximum of I periods. Individuals differ in age, $i \in \{\kappa, \dots, I\}$, where κ is the age at which an individual enters adulthood. Conditional on being alive at age $i - 1$, the probability of surviving to age i is s_i and population grows at the rate n . The measure of individuals in age group i at time t is given by $\mu_{i,t}$.

3.2 Preferences, technology and markets

Individuals derive utility from a standard consumption good and leisure. Preferences are time separable. The instantaneous utility function takes the form $u(c, 1 - h)$, where c is current consumption and h is the time spent working in the market. The function $u(\cdot, \cdot)$ is increasing and strictly concave in both arguments.

An agent maximizes lifetime utility as given by

$$\max_{\{c_i, h_i\}, R} \sum_{i=\kappa}^I \beta^{i-\kappa} \pi_i u(c_i, 1 - h_i) \quad (3.1)$$

subject to the intertemporal budget constraints to be specified below. R is the retirement age defined as the age at which the individual chooses to stop working ($h_i = 0$). π_i is the unconditional probability for an agent of being alive at age i ,

defined as $\pi_i \equiv \prod_{j=\kappa}^i s_j$. Upon death, individuals get zero utility.

Individuals invest their assets in a perfect annuity market which pays a premium of $\frac{1}{s_i}$ on the gross interest rate.

Output in period t is given by a standard constant returns to scale production function $f(K_t, L_t)$ with aggregate labor, L_t , and capital, K_t , as inputs. Output is used for consumption and investment in capital formation. Aggregate labor input in period t , L_t , is the sum of efficiency units supplied by individuals, i.e. $L_t = \sum_i e_{i,t} h_{i,t} \mu_{i,t}$ where $e_{i,t}$ is the number of labor efficiency units and $h_{i,t}$ is the time spent working by individuals of age i in period t . Representative firms rent labor and capital on the spot markets at a given wage rate, w_t , and a gross rental rate, r_t , and the firm solves

$$\max_{K_t, L_t} \{f(K_t, L_t) - (r_t + \delta) K_t - w_t L_t\}$$

where δ is the depreciation rate of capital.

3.3 Government and social security

Government policy consists of a tax rule, a public spending rule, and a transfer rule including social security and other government transfer programs. The tax rule specifies an exogenous payroll tax rate τ_S , and an endogenous tax rate τ on capital income and labor income.

Social security is modelled to capture the salient features of the U.S. social security system. At some age, J^E individuals become eligible for social security benefits. Only eligible individuals who are retired ($h = 0$) can receive social security benefits. The individual's social security transfer is a function $\Omega(\bar{y}, R)$ of her average earnings during worklife and her age at retirement, R . $\Omega(\cdot)$ is (weakly) increasing in R , such that a premium may be given for delayed retirement. The premium given for delayed retirement may vary by age.

All other government transfer programs, such as medicare, unemployment insurance, welfare payments etc., are distributed as part of the lump-sum transfers ξ .

The aggregate social security benefits and other government transfers in period t can be computed as

$$T_t = \sum_i (\mu_{i,t} (\xi + \Omega(\bar{y}, R_{t-i+1}))) \quad (3.2)$$

where \bar{y} is average life-time earnings and R_{t-i+1} is the retirement age of an individual born at time $t - i + 1$. For simplicity average life-time earnings, \bar{y} is computed over the first \bar{J} years of work life, $\bar{y} = \frac{1}{\bar{J}} \sum_{i=\kappa}^{\bar{J}} w_t e_i h_i$. Finally, the government can allocate resources to government consumption, G_t . Total tax revenues are given by

$$REV_t = \tau (w_t L_t + r_t K_t) + \tau_S w_t L_t \quad (3.3)$$

where L_t and K_t are respectively aggregate labor input and aggregate capital, respectively.

Budget deficits are financed through increases in tax-exempt government bonds B_t . Bonds are held by private agents and evolve according to

$$B_{t+1} = B_t(1 + r_t(1 - \tau)) - REV_t + T_t + G_t \quad (3.4)$$

where market clearing in the bonds market has been imposed, i.e. $r_t^B = r_t(1 - \tau)$.

3.4 Individuals' budget constraint and decision problem

The budget constraint of an individual of age i at time t is

$$c_{i,t} + a_{i+1,t+1} \leq a_{i,t} \frac{1}{s_{i,t}} + m_{i,t} \quad (3.5)$$

where $m_{i,t}$ denotes individual i 's after-tax income at date t , $a_{i,t}$ denotes i 's asset holdings in period t , and $\frac{1}{s_{i,t}}$ captures the survivor's premium implied by the perfect annuity markets. Initial wealth is zero. Subsequently, an individual has four potential sources of income: labor earnings, interest income, lump-sum transfers and social security benefits. Thus,

$$m_{i,t} = \begin{cases} r_t(1 - \tau) a_{i,t} \frac{1}{s_{i,t}} + w_t \varepsilon_i h_{i,t} (1 - \tau_S - \tau) + \xi_i & \text{if } \omega_{i,t} = 0 \\ r_t(1 - \tau) a_{i,t} \frac{1}{s_{i,t}} + \xi + \Omega(\bar{y}, R_{t-i+1}) & \text{if } \omega_{i,t} = 1 \end{cases}$$

where $\omega_{i,t}$ takes on the value of 1 if individual i has chosen to receive OAI benefits at time t , and 0 otherwise.⁴ In other words, whenever $\omega_{i,t} = 1$ the individual is

⁴ An implicit assumption embodied in the budget constraint is that a beneficiary cannot work, i.e. $h\psi = 0$. Empirically, around 73% of the beneficiaries aged 65-69 did not work in 1989 (Friedberg, 1999). An equivalent assumption is that a 100% labor tax is levied on beneficiaries. At least two features of reality can motivate such an assumption: 1) in addition to federal and state taxes, the retirement earnings test levies a 33-50% marginal tax on labor supply on 62-64 year old beneficiaries who work, and 2) the existence of technological constraints preventing a low number of hours of work.

considered retired. The retirement age of an individual born at $t - i + 1$ is defined as $R_{t-i+1} \equiv \min \{\kappa \leq i \leq I \mid \omega_{i,t} = 1\}$. It will be assumed that the retirement decision is irreversible, i.e. that $\omega_{i,t} = 1$ for $i \geq R_{t-i+1}$. Irreversibility considerably simplifies the problem.

The state of an individual can be summarized by the 3-tuple (a, \bar{y}, i) . Given prices, policies, transfers and the initial conditions, a worker's value function, $v_t^{\mathcal{W}}$, is the solution to the following recursive problem

$$v_t^{\mathcal{W}}(a, \bar{y}, i) = \max_{(a', c, h, \omega)} \{u(c, 1 - h) + \beta s_i [\omega v_{t+1}^{\mathcal{W}}(a', \bar{y}', i + 1) + (1 - \omega) v_{t+1}^{\mathcal{R}}(a', \bar{y}', i + 1)]\} \quad (3.6)$$

subject to

$$c + a' \leq (1 + r_t(1 - \tau)) a \frac{1}{s_i} + w_t \varepsilon_i h (1 - \tau_S - \tau) + \xi_i, \quad \omega = 0 \quad (3.7)$$

$$\omega \in \{0, 1\} \quad (3.8)$$

$$a = 0, \quad i = \kappa \quad (3.9)$$

$$a' \geq 0, \quad i = I \quad (3.10)$$

$$\bar{y}' = \frac{w_{t+1}}{w_t} \bar{y} + \frac{1}{\bar{J}} w_{t+1} \varepsilon_i h, \quad i \leq \bar{J} \quad (3.11)$$

$$0 \leq h \leq 1 \quad (3.12)$$

and

$$v_t^x(a, \bar{y}, I + 1) = 0, \quad x \in \{\mathcal{W}, \mathcal{R}\} \quad (3.13)$$

The worker's problem is standard, except for the retirement decision, ω , and equation (3.11). Equation (3.11) updates the individual's average earnings indexed to the growth rate of wages in the economy, $\frac{w_{t+1}}{w_t}$. Note that social security indirectly affect labor supply incentives, since average earnings determines the social security benefits received during retirement.

A retiree solves the following recursion

$$v_t^{\mathcal{R}}(a, \bar{y}, i) = \max_{(a', c)} \{u(c, 1) + \beta s_i [v_{t+1}^{\mathcal{R}}(a', \bar{y}, i + 1)]\} \quad (3.14)$$

subject to

$$c + a' \leq (1 + r_t(1 - \tau)) a \frac{1}{s_i} + \xi + \Omega(\bar{y}, R), \quad \omega = 1 \quad (3.15)$$

and (3.9), (3.10) and (3.13).

3.5 Definition of Equilibrium

This section describes the conditions jointly characterizing the steady state of the economy at date $t = 0$.

Given initial conditions for debt B_0 , the distribution of assets a_0 , population distribution μ_0 , and government policies $\Psi = (\xi, G_t, \tau_S, \Omega(\cdot))$, an equilibrium is defined as a sequence $\left\{ w_t, r_t, L_t, K_t, A_t, B_t, \{h_{i,t}, c_{i,t}, a_{i,t}, \omega_{i,t}\}_{i=\kappa}^I \right\}_{t=0}^{\infty}$, and a tax rate τ , such that the following holds

1. $\{h_{i,t}, c_{i,t}, a_{i,t}, \omega_{i,t}\}_{i=\kappa}^I$ solves the individuals' maximization problem, i.e. (3.6) and (3.14), given w_t, r_t and government policies (Ψ, τ) .
2. Factor markets clear

$$w_t = \frac{\partial f(K_t, L_t)}{\partial L_t} \quad t = 0, 1, \dots$$

$$r_t = \frac{\partial f(K_t, L_t)}{\partial K_t} - \delta \quad t = 0, 1, \dots$$

3. The goods market clears every period

$$f(K_t, L_t) + (1 - \delta) K_t = K_{t+1} + G_t + \sum_{i,q} \mu_{i,q,t} c_{i,q,t} \quad t = 0, 1, \dots$$

4. The tax rate τ solves the government's feasibility constraint

$$B_0 = \sum_{t=0}^{\infty} \frac{REV_t - G_t - T_t}{\prod_{j=0}^t (1 + r_j)} \quad (3.16)$$

where REV_t is given by (3.3) and T_t by (3.2).

5. The market for savings clears

$$K_t = A_t - B_t \quad t = 0, 1, \dots$$

where $A_t = \sum \mu_{i,q,t} a_{i,q,t}$.

Table 3.1: Calibration

	Parameter	Value
Population	κ	20
	I	100
	Mortality	NCHS, Year 2000
Preferences	(ψ, γ)	(3.7, 4)
	σ	2
	β	0.9935
Technology	α	0.36
	δ	0.079
	K/Y	2.7
Government	G_t/Y_t	14.4%
	T_t/Y_t	11.2%
	θ	42%
	τ_S	15.3%
	B_t/Y_t	47.9%

4 Calibration

The model is calibrated to capture features of the U.S. economy in the year 2000. This section discusses the procedure used to calibrate the model. Table 3.1 provides an overview of the calibration choices. The economy is assumed to be in a steady state in the year 2000.

4.1 Demographics

Individuals are born into the economy at the age of $\kappa = 20$ and die for sure at the age of $I = 100$. The survival probabilities are taken from the Social Security Administration (2003) and correspond to the cross-section survival probabilities in the year 2000. The population growth rate is set to $n = 0.018$ chosen to match the ratio between the population aged above 65 to 20-64 year olds at around 20% (SSA (2003)).

4.2 Productivity

Hansen's (1993) method for estimating productivity profiles of prime age workers is by now standard in the literature. However, estimating productivity profiles for older workers is considerably more problematic. First of all, data on wages and hours worked for older workers is scarce. But more importantly, self-selection problems are likely to yield biased estimates. Fortunately, French (2005) has carefully estimated

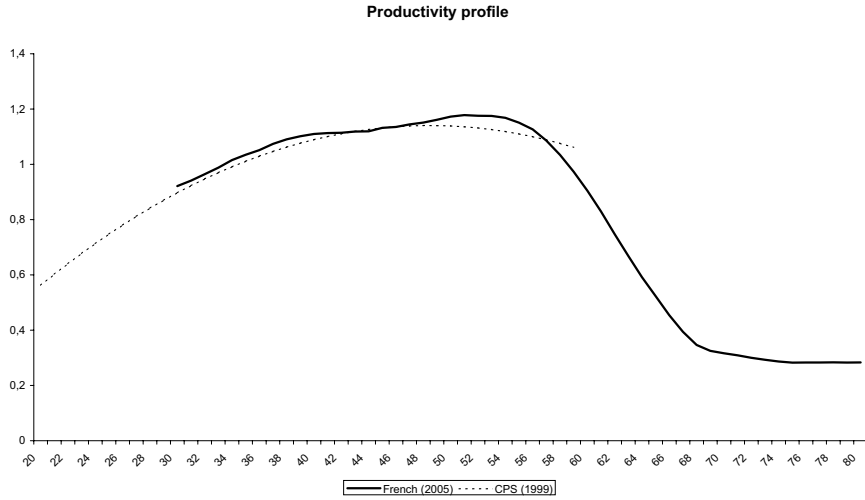


Figure 3.5: Productivity Profile

productivity profiles accounting for selection bias. His estimates will be used here. However, he only estimates productivity for those aged above 29. For this reason, a productivity profile for 20-60 year olds is estimated using data from Census (1999) and a method related to Hansen (1993). Both profiles are displayed in Figure 3.5.

French's profile is then used together with the estimate from Bureau of the Census (1999) for 20-29 year olds. This productivity profile is assumed to be time invariant.

4.3 Technology and Utility function

Preferences are standard from the microeconomic literature on labor supply. The instantaneous utility of an agent is additively separable in consumption and leisure

$$u(c_t, 1 - h_t) = \frac{c_t^{1-\sigma}}{1-\sigma} + \psi \frac{(1 - h_t)^{1-\gamma}}{1-\gamma} \quad (3.17)$$

This functional form has the attractive property that both hours worked and the elasticity of labor supply can be calibrated in accordance with empirical estimates. The parameters $(\psi, \gamma) = (3.7, 4)$ together imply that (a) the average labor supply for 20-60 year olds is 31 hours/week, i.e. the same as the average hours worked in year 2000 for the U.S. population (U.S. Bureau of the Census (1999)), and (b) that the implied Frisch elasticity is 0.56. This is close to the Frisch elasticity of 0.64 estimated by Heathcote et al (2004). The coefficient of relative risk aversion σ is set at 2.

The production technology is a standard Cobb-Douglas, $K_t^\alpha L_t^{1-\alpha}$, where capital's share is assumed to be $\alpha = 0.36$. Using estimates from Prescott (2004) the target for the capital-output ratio is set at 2.7. McGrattan and Prescott (2002) compute an interest rate (net of taxes) of 4%. These targets are achieved in this model by setting $\beta = 0.9935$ and the depreciation rate $\delta = 0.079$.

4.4 Government

Government consumption, G_t , is assumed to be 13.4% of GNP in the initial steady state, the same as in 2000 (BEA (2005)).⁵

All workers are assumed to be enrolled in social security. Social security benefits are a function of previous earnings and the age of retirement, $\Omega(\bar{y}, R)$, where $\bar{y} = \frac{1}{40} \sum_{i=1}^{40} w_i h_i e_i$ are the average earnings over the 40 first years of working life.⁶ Upon retirement at the Full Retirement Age (FRA), benefits are provided as a flat replacement rate on average earnings, $\theta \bar{y}$. The replacement rate is $\theta = 0.42$ based on data from the Social Security Administration. The SSA (1998) have computed replacement rates for hypothetical average workers for various years.⁷ The Full Retirement Age (FRA) is set at 65. However, workers are eligible for social security benefits at reduced rates from the age of 62. Benefits are reduced by 2/30 for each year before FRA that the individual chooses to retire (reduction for early retirement, RER). Moreover, if a worker chooses to delay retirement beyond the age of 65, she will get a delayed retirement credit (DRC) of 6% per year until the age of 70. This implies that the monthly social security benefits received by a retiree are \$940.⁸ It is important to model the DRC/RER to get internal solutions for the retirement problem. Without DRC/RER, individuals retire at the age of 62, the earliest eligibility age. The calibration implies that social security transfers stand at 5.3% of GNP in the year 2000 economy.

According to the data, total non-social security transfers stood at 11.2% of GNP in the year 2000. It will be assumed that these are evenly distributed across all individuals as lump-sum transfers.

⁵ Computed as consumption expenditures less current transfer receipts (primarily fines, fees and donations) .

⁶ This specification is chosen because it makes the subsequent calibrations of replacement rates straightforward.

⁷ The replacement rates are based on the Primary Insurance Amounts of hypothetical workers, who retired at the FRA after full-time careers with steady earnings equal to average earnings in the economy.

⁸ The average OAI benefit for a newly retired individual was \$880 in 2000 (SSA (2001)).

The initial debt is set at 47.4% of GNP, equal to the net financial liabilities of the US government at the end of 1999 (OECD (2004), BEA(2005)).

The payroll tax, τ_S , is set to 15.3%, equal to the actual combined medicare and OASDI payroll tax (employer and employee).

The government sets taxes to balance its budget constraint. Given expenditures, other tax policies and initial debt, the implied tax rate is then $\tau = 26.9\%$ and the associated tax revenue is 27.2 percent of output.⁹

5 The Experiment

In the previous section, the economy was calibrated to capture features of the U.S. economy for the year 2000. In this section, we will study the historical trends in fiscal policy and their effects on retirement behavior. The model will be run for the period 1900-2000, only changing policies and survival probabilities. Thus, all preference and technology parameters are held constant for this experiment. For clarity we consider steady states. An extension with transitional dynamics is considered in sub-section 5.3. For seven decades during the twentieth century, steady states are computed. A minimum of observable government policy variables will be changed. In particular, we will vary the government's debt-to-output ratio, the government's consumption spending, and transfers, including some features of the social security system. Finally, the mortality rates will be changed in accordance with the data.

Section 5.1 explains the historical developments of relevance for the experiments and the implementation, while section 5.2 discusses the results.

5.1 Trends in Fiscal Policy

The twentieth century was characterized by the rise of government in the United States and many other Western countries. Wallis (2000), for instance, estimate that U.S. government revenue (local, state and national) increased from 4.2% of GNP in 1850 to 7.2% at the turn of the nineteenth century, and rose to 37.5% in 1992. The growth rate of government revenue and spending was particularly high during the first half of the twentieth century, around 2.2 percent per year. Between 1952 and 1992 the growth rate was 0.7 % per year.

⁹ The average tax revenue 1998-2002 was 28.3 percent of GNP (BEA, 2005). This is computed as current tax receipts plus contributions for government social insurance less taxes from the rest of world. In 2000, the tax revenues stood at 29.4 percent of GNP and the surplus was 2.3 percent of GNP.

Table 3.2: Government Expenditures and Debt, 1930-2000, Percent

	1900	1930	1940	1950	1960	1970	1980	1990	2000
D/Y	11.0	21.0	42.4	94.1	56.1	37.6	33.3	49.9	47.9
G/Y	3.7	7.4	10.5	12.5	15.7	18.2	16.5	16.5	14.4
T/Y	0.5	1.0	2.9	6.0	5.5	7.8	10.2	10.5	11.2

Sources: Debt: OECD(2005), ERP(2004), $G/Y+T/Y$: BEA(2005).

Note: The 1900 figure for T/Y and G/Y is set as half the 1930 value.

Wallis (1984) documents that total government expenditures doubled between 1902 and 1930.

5.1.1 Debt and Government Expenditures

It will be assumed that the fiscal developments, other than social security, can be adequately summarized by changes in government consumption, lump-sum transfers and debt policy. Table 3.2 displays the historical measures that will be used in the subsequent calibration exercise.

In general, there was an increasing trend in government transfers and government consumption between 1900 and 1980. After 1980, expenditures stabilized and even dropped somewhat towards the end of the century. The debt-to-output ratio increased between 1900 and 1950, primarily due to the world wars. Between WWII and the 1980s, the debt-to-output ratio declined, but once more rose to around 50% of GNP at the end of the century.

In the calibration, these figures will be matched exactly, and the general tax rate, τ , will be endogenously determined to satisfy the government's budget constraint.

5.1.2 Social Security

Although the seeds were sown for the United States social security system by the Social Security Act of 1935, it took decades for the system to mature. Below, the evolution of social security will be described in some detail.

In the model, it will be assumed that the historical evolution of social security can be described by six parameters. These are variables that the microeconomic literature has identified as being potentially important for the retirement decision: payroll tax (τ_S), eligibility ages (FRA, ERA), premium to/punishment for delaying/bringing forward retirement (DRC/RER) and replacement rate θ . Table 3.3 below displays the parameter values for social security. The parameter choices will be further motivated below.

Table 3.3: Social Security Assumptions, 1900-2000

	1900	1930	1940	1950	1960	1970	1980	1990	2000
θ	0	0	0	0	0.33	0.34	0.51	0.43	0.42
τ_S (%)	0	0	1	3	6	9.6	12.3	15.3	15.3
DRC (%)	none	none	0	0	0	1.0	3.0	3.5	6
RER (%)	none	none	0	0	0	6.7	6.7	6.7	6.7
ERA	none	none	65	65	65	62	62	62	62
FRA	none	none	65	65	65	65	65	65	65

Sources: SSA(2005), SSA(1998).

1940 and 1950 The U.S. Social Security system was launched in 1940. However, during the first ten years, benefits were very uncertain and the eligibility rules were restrictive. First, benefits had been fixed at their 1940 level, in an environment where the average inflation rate was about 5.6% a year (the standard deviation was 5) (BLS (2005)). As a result, the replacement rate, computed as the ratio between benefits and the average earnings in the economy, decreased from around 23% in 1940 to only 11% in 1949.

Second, only workers in industry and commerce were covered under the system. Thus, at most 25-32% of the cohort that would reach the eligibility age (65) in 1950, had worked in covered employment during the 1940s.¹⁰ Moreover, a minimum of work effort and income was required to become eligible.¹¹ Therefore, 32% can be considered an upper bound for the fraction of eligible in the cohort.

For these reasons, it will be assumed that there were no social security benefits available in 1940 and 1950. This can be considered a conservative choice, since all changes in retirement behavior during this period must be driven by other policies. The payroll tax, on the other hand, will be assumed to be 1% in 1940 and 3% in 1950, as in the data.

1960 It was only during the 1950s that social security expanded. The 1950 Amendments significantly increased the replacement rate and made social security available to a larger share of the population. As a result, the fraction of insured in the population increased to 72% in 1960. In the same year the replacement rate was 33.3%. The

¹⁰ This is computed as follows. In 1940 [1945], the number of 55-59 [60-64] year olds working in covered employment was 1,488,000 [1,757,000], while the population in the same age group was 5,844,000 [5,500,000] (SSA(2005)), Hopps and Stoops (2002)). Thus, 25%-32% of the population were working in covered employment during the 1940s.

¹¹ To be eligible for OAI benefits, a worker was required to have worked in covered employment at least one-half of the quarters elapsed between 1936 and her 65th birthday, earning more than \$50 per quarter (the median annual wage in covered employment was \$746 in 1940, equivalent to \$186 per quarter).

replacement rates reported in table 3.3 are for a hypothetical worker with average earnings.

In 1960, the early retirement age (ERA) and the full retirement age (FRA) coincided at the age of 65, and there was no delayed retirement credit (DRC) or reduction for early retirement (RER).

1970 By 1970, the replacement rate stood at 34%. Moreover, ERA had been reduced to the age of 62 in 1961, and the RER and DRC stood at 1% and 6.7%, respectively.

1980 The years between 1970 and 1980 were a period of consolidation for the social security system. Due to over-indexation of benefits, the replacement rate was high in 1980, at 51%. DRC rose to 3% in 1980.

1990 and 2000 Although a number of important reforms were introduced during the 1980s and 1990s, most of these were intended to affect cohorts retiring after the year of 2000. The replacement rates stabilized at around 42-43%. Moreover, DRC changed – to 3.5% in 1990 and 6% in 2000.

5.1.3 Mortality rates

The mortality rates also changed dramatically during this period, which will be important for two reasons. First, this changes the demographic composition of the population. As time passes a larger fraction of the population will be older and have higher savings. This affects the interest rate and therefore retirement. Second, mortality directly affects the individual's retirement choice. Higher survival probability reduces the return to annuities; a negative wealth effect which tends to delay retirement.

It will be assumed that the demographic developments can be described by the cross-sectional mortality rates for the respective years. Thus, life expectancy at birth increases from 47 in 1900, to 68 in 1950, and 77 in the year 2000. Mortality rates are directly related to the old-age dependency ratio, computed as the number of 65+ to the 20-64 year olds in the population. In the model, this ratio increases from 2% in 1900 to 20% in year 2000.

Table 3.4: Selected Statistics from the Model Economies

	1900	1930	1950	1960	1970	1980	1990	2000
R	71.00	72.24	71.00	64.76	64.37	62.58	64.13	64.26
r^{net} (%)	3.63	3.57	3.89	4.28	4.11	4.30	4.26	4.0
w	1.07	1.06	1.01	0.98	0.98	0.96	0.97	1.00
K/Y	3.1	3.0	2.8	2.6	2.6	2.5	2.58	2.7
τ (%)	5.9	11.6	25.2	28.0	29.0	32.0	29.4	26.9

5.2 Results

Table 3.4 displays selected results from the model economies. The rise in government results in increasing tax rates, especially during the first half of the century. Moreover, the radical change in debt policy and the rise in capital taxation crowd out capital, which implies that the capital-to-output ratio declines from 3.1 in 1900 to 2.6 in 1960 and the interest rates rise from 3.6% to 4.28% in 1960.

5.2.1 Retirement Behavior

Table 3.4 reports the optimal retirement age for individuals in the steady states. Since the model is set in one-year periods, cubic splines have been used to generate a continuous measure of retirement age.¹² Notice that the model does a reasonably good job in tracking the average retirement behavior since the beginning of the twentieth century. This can also be verified in Figure 3.6. In 1930, the model predicts a retirement age of 72.2, while in the 1950 economy the retirement age declines to 71. Upon introducing social security in the 1960 economy, the retirement age drops sharply to 65. After the early eligibility age is reduced to 62, from 1970 and onward, the retirement age stabilizes at around 63-64. Relative to the measure computed in section 2, the model over-estimates the retirement age before WWII and after 1980. The retirement age is grossly under-estimated in the year 1900 economy.

What can account for the trends in retirement according to the model? From the viewpoint of the individual, six objects change between the steady states: the interest rate, the wage rate, the two tax rates, the survival probabilities and the social security system. Table 3.5 decomposes the change in the retirement age into these six sources of change. The table is constructed by changing prices, policies or mortality rates one at a time, and computing the optimal retirement response. For instance, at the prices, policies and survival rates prevailing in 1930, the optimal retirement age is 72.2. Column II of table 3.5 shows that increasing the interest rate

¹² The method interpolates between the value functions at different (integer) retirement ages.

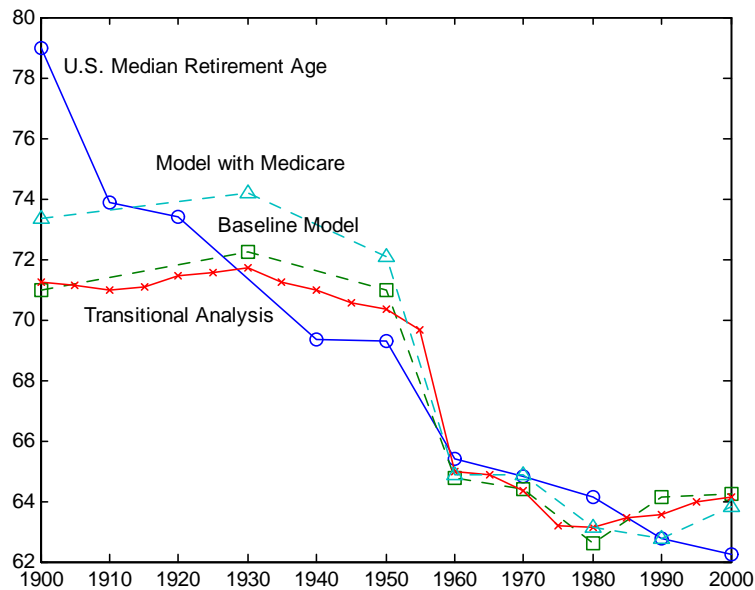


Figure 3.6: The Evolution of Retirement, 1900-2000, Model and Data

from 3.6% in 1930 to 3.9% in 1950, *ceteris paribus*, implies a five-year reduction in the optimal retirement age (from 72.2 to 67.2). On the other hand, the increase in the general tax rate from 11.6% to 25.2%, *ceteris paribus*, delays retirement by five years (from 72.2 to 77). It must be emphasized that the partial effects in general do not add up to the total effect, since retirement responses are non-separable functions of the objects.

Table 3.5 is very useful for interpreting the developments in retirement behavior over the twentieth century. According to the model, the reduction in the retirement age between 1930 and 1950 was driven by the dramatic change in government debt policy and the increase in capital taxation. Both policies crowded out capital resulting in higher interest rates, a positive wealth effect, thereby making retirement more attractive. However, there were also forces in the opposite direction. First, the increase in τ provided incentives to delay retirement, since (a) the tax is partly levied on capital, so that an increase effectively reduces the net return to savings, and (b) the income effect dominates ($\sigma > 1$), so that the increase in labor taxation reduces the demand for leisure, including retirement. Second, the increase in survival rates implied that the return to annuities decreased, which also made retirement less attractive. However, the interest rate effect dominated, and individuals brought forward retirement by one year and three months, to retire at the age of 71.

Table 3.5: The Sources of Change in Retirement (No. of Years Relative to Base Year)

	1900 – 1930	1930 – 1950	1950 – 1960	1960 – 1970	1970 – 1980	1980 – 1990	1990 – 2000
Δr^{net}	-2.01	-5.04	-3.00	+0.01	-1.73	+0.01	+0.31
Δw	0	+0.76	0	0	+0.01	0	-0.02
$\Delta \tau$	+3.00	+4.76	+1.25	+0.01	+0.08	-0.05	-1.43
$\Delta \tau_S$	0	+0.76	+0.52	0	0	0	0
$\Delta \{s\}$	+0.53	+0.76	0	0	+0.01	+0.09	+0.18
ΔSS	-	-	-6.20	-2.24	-1.76	+0.09	-0.34
Total	+1.24	-1.24	-6.24	-0.39	-1.79	+1.55	+0.13

Note: The change is computed as $R_{t+1} - R_t$, so that positive numbers imply a delay in retirement. The sum of the effects do not necessarily add to the total.

When social security is introduced into the model in 1960, the retirement age drops sharply to 64.8. Column III in table 3.5 shows that, indeed, the change was driven by the introduction of social security; first, because the introduction of social security in itself provided strong financial incentives to retire and second, because social security reduced the incentives to save, thereby crowding out capital. This resulted in higher interest rates and therefore, earlier retirement. However, these effects were mitigated by the increase in taxes.

In the 1970 economy, the early eligibility age was reduced to 62 and DRC/RER were introduced. The combined effect reduced the retirement age by nearly two additional years.

In the 1980 economy, the high replacement rate also provided incentives to retire earlier. In addition, an increase in the interest rate created by an increase in capital taxation and by crowding out of savings due to the high replacement rate, resulted in a reduction in the retirement age to 62.6.

The findings for the changes in retirement behavior between 1980 and 1990 are somewhat puzzling at first. According to Column VI of table 3.5, the changes in prices only have a marginal impact on retirement behavior, indicating that the retirement age would change by at most 1-2 months. Yet, the combined effect was a delay in retirement of one and a half years. The explanation can be appreciated by plotting the value functions for retirement at different ages; see Figure 3.7. Notice, that the value function is nearly flat between the ages 62.8 and 64.2 (model age 42.8 and 44.2). Thus, the individual is almost indifferent between retiring at the age of 63 or at the age of 64. This also implies, that relatively small changes in prices/policies can cause large retirement responses. In the 1980 economy, the partial changes in prices/policies were not sufficient to generate large responses in retirement, while their combined effect was.

The retirement age hardly changes between the 1990 economy and the year 2000 economy. While the lower general tax rate and the reduction in the replacement rate provided incentives to retire earlier, this was counteracted by the increase in interest rates and survival rates.

Table 3.6 considers the change between the early twentieth century and year 2000. The table clearly suggests that social security was a main driving force in the evolution of retirement since 1950. Primarily due to social security incentives, but also because social security crowded out savings and increased interest rates. The table also suggests that the drop in retirement between 1930 and 1950 was due to the increase in interest rates. The increase in interest rates was primarily caused by

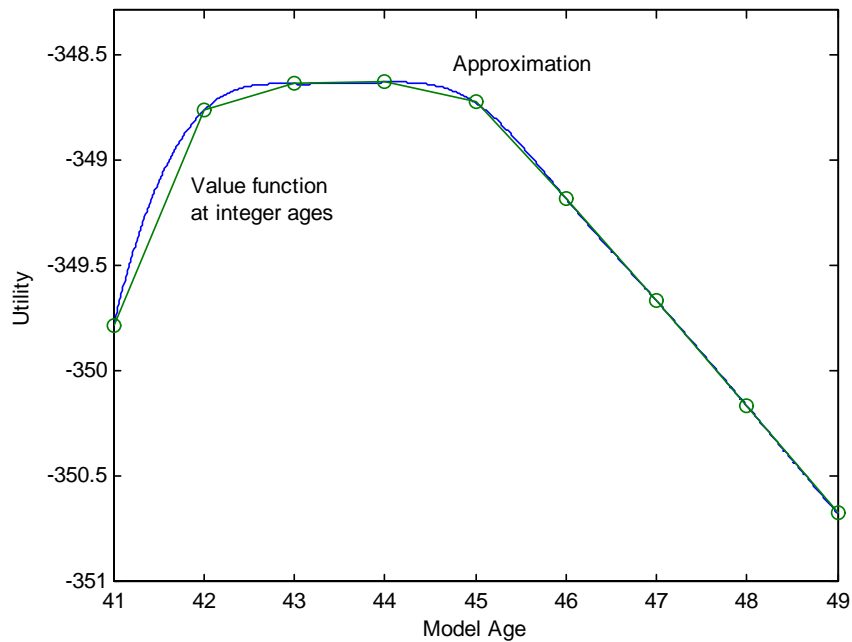


Figure 3.7: Value function at different retirement ages, Real Age 61-69 (Model Age, 41-49), 1980 Economy.

the dramatic increase in government debt from 21% of GNP in 1930 to 94% in 1950.

Table 3.6: Sources of Change in Retirement (No. of Years)

	1930-1950	1950-2000
Δr^{net}	-5.04	-2.1
Δw	+0.76	0
$\Delta \tau$	+4.76	+0.62
$\Delta \tau_S$	+0.76	+2.0
$\Delta \{s\}$	+0.76	+0.63
ΔSS	-	-5.85
Total	-1.24	-6.74

See note for Table 3.5

5.2.2 Labor Supply

It is also interesting to look at the evolution of labor supply over the life cycle in the twentieth century. Figure 3.8 depicts profiles of life cycle hours worked for the different steady states. As the century passes, the profile of life cycle labor supply shifts clock-wise. As people enter earlier into retirement, they also tend to work more during their work life, both due to intertemporal substitution of leisure from

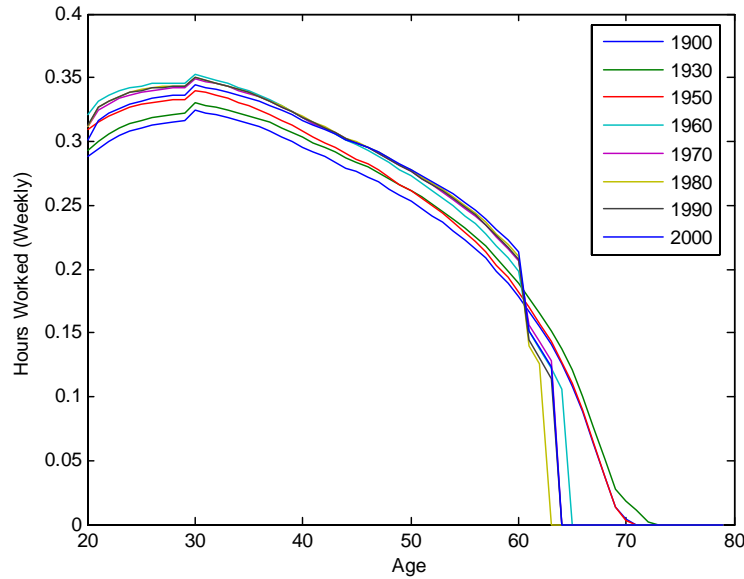


Figure 3.8: Weekly Hours Worked, 1900-2000

prime-age to old age, and to increases in taxes on labor which drive up the hours worked.

It is interesting to compare this figure with the profiles of hours worked constructed by McGrattan and Rogerson (2002) (see Figure 3.9). McGrattan and Rogerson construct profiles of hours worked for cohorts born 1866 to 1985 in the United States.¹³ The pattern of labor supply shifts clockwise as in the model. Quantitatively, the model appears to be consistent with the reduction in hours worked among the elderly. The model can only account for the rise in hours worked among workers to a limited extent.

5.3 Some Additional Results

The model is roughly consistent with the labor supply pattern among older workers in the past century. This section presents some additional results. First, the economies considered in the previous section were steady state economies. Obviously, it is a stretch to argue that the U.S. economy was in a steady state at any of these points in time. Therefore, a transitional analysis is carried out. The economy is assumed to start out in a steady state in 1850 without a government. Then, in 1851 new policies and survival rates are unanticipatedly announced. It is assumed

¹³ An extrapolation procedure is used for cohorts for which data is missing.

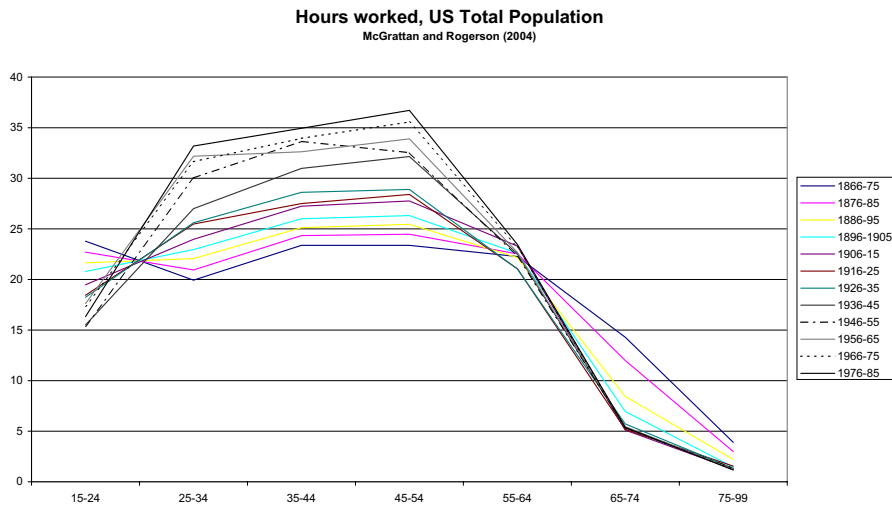


Figure 3.9: Hours Worked by Cohort and Age, U.S. Population, 1866-1985.

that the survival rates converge to the cross-sectional survival rates in the year 2000 economy. Moreover, the debt-ratio, government consumption ratio, and transfer ratios evolve linearly over the ten-year intervals. Individuals are assumed to fully anticipate all changes in prices and policies.

The results for the retirement ages are presented in figure 3.6 together with the baseline.¹⁴ We see that the retirement age follows a somewhat lower trajectory compared to the Baseline model. The reason is, that individuals realize that interest rates will rise and that social security benefits will be available and adjusts their consumption plans accordingly. Upon the introduction of social security, there is once more a discrete jump in the retirement age, but less so because individuals have anticipated the reform.

The model did not do well in matching the retirement age for the year 1900. The model, as constructed, abstracts from an important transfer program, namely medicare. Medicare constitutes one of the single most important transfer programs in old age. Storesletten (2000) estimates medicare transfers as a share of GNP per capita, by age; see Figure 3.10. This profile can have important implications for savings behavior, to the extent that individuals consider it a substitute for savings. In particular, introducing medicare into the economy helps us to create a larger gap in interest rates between the initial year and the final year of the economy. Since

¹⁴ The numbers are not directly comparable, since there are cohort and time effects in the transitional analysis. The graph for the transition displays the retirement age of the cohort turning 65 in the given year.

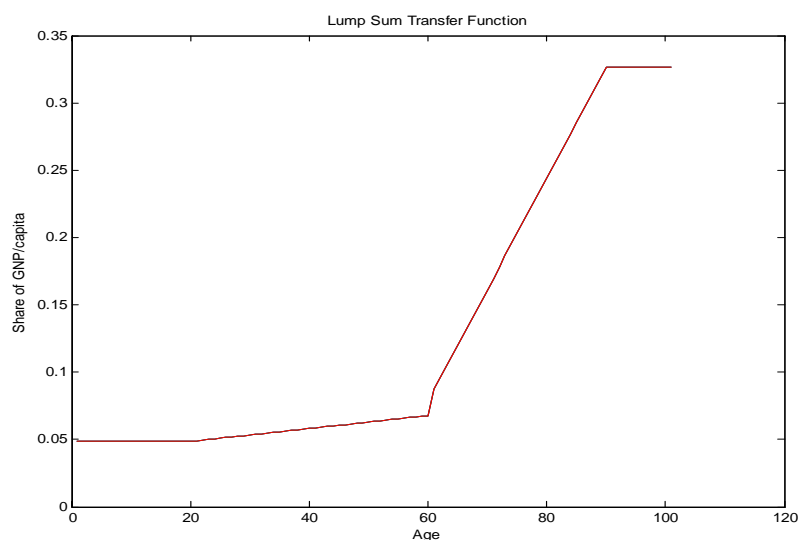


Figure 3.10: Medicare Transfer by Age, Share of GNP per Capita.

interest rates is an important determinant of the retirement age, this may give us some leeway in terms of the retirement age. Therefore, the following experiment was conducted. The economy was re-calibrated to the year 2000, adding medicare into the government's transfer program. Medicare is assumed to be provided lump sum according to the function estimated by Storesletten (2000). Figure 3.6 presents the results for the retirement age with medicare. Individuals now retire much later initially.

6 Two Puzzles

The model developed here is capable of matching the general trend in retirement over the twentieth century. Previous literature has questioned whether social security is responsible for the evolution in retirement. First, microeconomic studies tend to find a very small effect of social security on retirement behavior. Second, the decline in labor force participation started already in the early twentieth century, long before social security was introduced. This section discusses these puzzles in view of the model.

Table 3.7: Retirement Elasticities

Study	Age Group	Year	Elasticity
Krueger and Pischke (1992)	60-68	1976-1988	~ 0
Hausman and Wise (1985)	58-63	1969-1979	0.23
Hurd and Boskin (1984)	60-64	early 1970s	0.71
Friedberg (1996)	66-80	1940 and 1950	0.25 – 0.42
Costa (1998)	66	1910	0.47
Costa (1998)	56	1900	0.73

Source: Costa (1998)

6.1 The Retirement Elasticity Revisited

Since the early 1970's, economists have devoted much attention to studying the effect of social security on retirement behavior. Reviews of the literature can be found in Feldstein et al. (2002), Krueger and Meyer (2002) and Friedberg et al. (1998). This section argues that the implications of the microeconomic studies are broadly consistent with the predictions of the model.

Table 3.7 provides selected estimates of the retirement elasticity found in the literature. The retirement elasticity as reported gives the percentage change in the probability of retirement, caused by a one percent increase in benefits.

Many of the early studies suffered from fundamental problems in their identification strategy. First, as pointed out by Mofitt (1987) and Krueger and Meyer (2002), studies that examine cross-sectional data necessarily estimate how the social security system at a given point in time influences retirement behavior ((e.g. Hurd and Boskin (1984), Boskin (1977)). Thus, since all individuals are covered by the same rules, all variation in social security benefits is due to differences in individual-specific characteristics (e.g. hard work, well paid jobs etc.), and not the social security system as such. Consequently, the elasticity estimated is likely to capture differences in such characteristics, rather than differences in benefit levels. Second, studies using longitudinal data tend to find large effects of social security on retirement (e.g. Hurd and Boskin (1984), Burtless (1986), and Anderson, Burkhauser and Quinn (1986)). However, as argued by Krueger and Meyer (2002), the negative correlation between labor force participation and benefits might very well be spurious.

In a very influential study, Krueger and Pischke (1992) try to avoid these problems by studying a particular cohort, the Notch Babies, that was covered by different rules. These rules, which were unanticipatedly implemented, specified up to 16% lower benefits for the Notch Babies. Yet, the downward trend in labor force participation continued unabated. In effect, the retirement elasticity found in this study

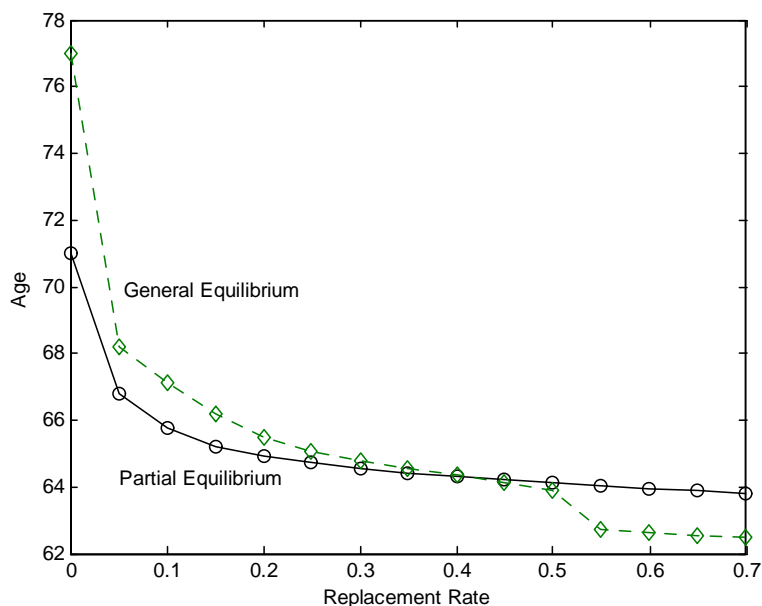


Figure 3.11: Optimal Retirement Age and the Replacement Rate

was nearly zero. Other studies find equally small elasticities, suggesting that between zero and one third of the declining trend in labor force participation can be explained by social security (Hausman and Wise (1985), Burtless (1986) and Mofitt (1987)).

Figure 3.11 depicts the retirement policy rule, $R(\theta)$, for the 2000 economy.¹⁵ The policy rule traces out the optimal retirement age for different levels of replacement rates, θ . The "Partial Equilibrium" line is constructed for given prices and taxes. The line can be interpreted as representing the microeconomic estimates. The "General Equilibrium" line is constructed by letting prices and taxes respond to the changes in individual behavior.

We see that the optimal retirement age is a decreasing function of the replacement rate. Moreover, the slope is decreasing at higher replacement rates. The slope is steeper for the general equilibrium case, because an increase in benefits crowds out savings, increases interest rates and therefore delays retirement. At the present level of the replacement rate, around 0.42, the retirement elasticity is indeed very low. A reduction in the replacement rate by 20% delays retirement by less than 3 months in the Partial Equilibrium case and 5 months in the General Equilibrium case. Interestingly, French (2003) estimates that a 20% reduction in benefits delays

¹⁵ The results are very similar in the other economies

retirement by around 3 months.

However, the small retirement elasticity does by no means imply that social security is unimportant for retirement behavior. To the contrary, abolishing social security would according to the model imply a delay in the retirement age of 7-13 years. Thus, the modest retirement elasticities found in the microeconomic literature, cannot be taken as evidence that social security has a small effect on retirement behavior.

6.2 Interest Rates in the Pre-Social Security Era

An important argument for why social security may not have been a main driving force for the labor supply behavior of older workers, is that the trend towards earlier retirement started already before social security was introduced (see Figure 3.3).

The model developed here suggests that the fall in labor force participation between ca. 1900 to 1950, was due to an increase in interest rates caused by the rise of government. This section looks at some of the empirical evidence in favor of this proposition.

The increase in government expenditures and government lending has already been documented in table 3.2. The model predicts rising interest rate from the early 1900s. Unfortunately, the evidence on yields of different assets before WWII is very scarce.

Figure 3.12 display the yields on long-term, high-grade municipal bonds from 1900 to 1950 taken from McGrattan and Prescott (2002). Although only a very small fraction of household assets – 0.7% in 1945 (FRB (2005)) – were held in municipal securities, it may provide an idea of the developments. We see that the yields increase over the period 1900 to 1934. Then, after 1934 they fell abruptly because of the Great Depression and remained low until the mid-1950s. McGrattan and Prescott (2002) forcefully argues that the low yields during WWII and the Korean War was a deliberate policy from the government's side, achieved through heavily regulated behavior of households and businesses. Thus, it may not be a good approximation for the returns to savings in this period.

Perhaps a better indicator is McGrattan and Prescott's (2002) estimate for the return on large company stocks. In 1945 15% of household assets were held in corporate equities (FRB (2005)). Figure 3.12 shows that the return to equity follows an increasing trend between 1900 and 1950.

Thus, there seem to be some evidence that returns to savings indeed increased

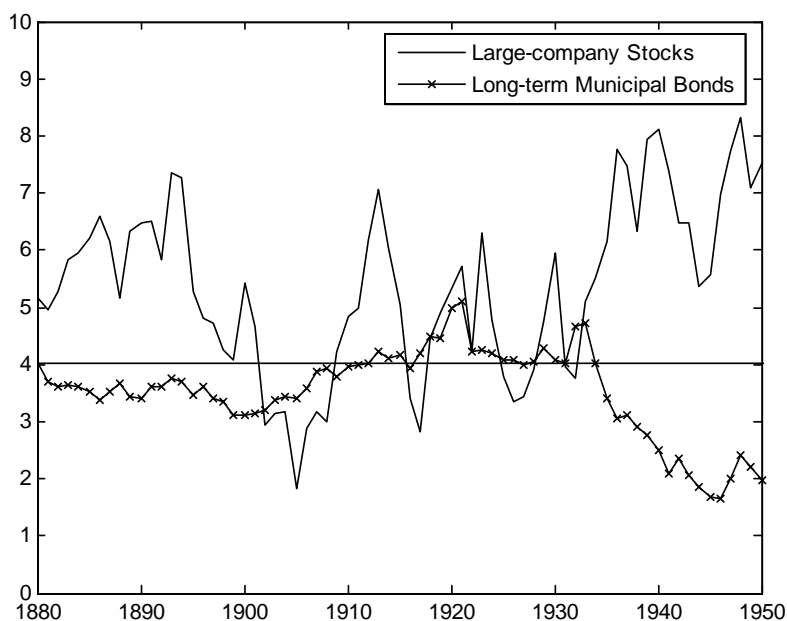


Figure 3.12: Debt Returns and Real Returns to Assets

between 1900 and 1950.

Whether or not the increase in interest rates was driven by the expansion of government is an unsettled question. However, for the post-war period a number of studies have documented that higher government debt indeed increased long term interest rates (Barth et al (1985), Zahid (1988), Cebula and Cock (1991, 1994), Bahmani-Oskooee (1994), Kalulumia (2000)).¹⁶

7 Conclusion

Social security has often been proposed as the main determinant of the declining trend in labor force participation among older workers. However, two puzzles must be addressed by anyone arguing that social security is the causal factor. First, microeconomic studies tend to find a very small effect of social security on retirement behavior. Second, the decline in labor force participation started already in the early twentieth century, long before social security was introduced.

¹⁶ A number of studies argue that there is no relation between government debt and interest rates (Evans (1985, 1987), Barro (1987), Deravi et al. (1990), Seater (1993), and Gulley (1994)). However, they primarily use short-term interest rates. Long-term interest rates are more relevant here: individuals usually save for their retirement in long-term assets.

This paper proposes a model that explains the trend in labor supply among older workers through changes in fiscal policy, including social security. The model emphasizes the general equilibrium effects of fiscal policy on retirement behavior. In particular, the radical shift in fiscal policy at the beginning of the century raised the returns to savings, which induced workers to retire earlier. The model predicts a large change in retirement behavior upon the introduction of social security, while subsequent increases in replacement rates are shown to have a small impact on retirement. Specifically, the retirement elasticity is found to be a decreasing and convex function of the replacement rate. Thus, the essay proposes social security as a major determinant of retirement behavior in the second half of the Twentieth century, while simultaneously offering an explanation of the two main puzzles in the literature.

The paper abstracts from features that are potentially important; e.g. productivity growth, imperfect annuity markets and bequest. Future work should consider extensions in this direction. Also, the mix between income taxation and capital taxation has changed considerably over time (McGrattan and Prescott (2002)). Since capital taxation is a main determinant of retirement behavior in the model, future work should explore the time variation in this dimension.

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Chapter 4

Sustainable Fiscal Policy and the Retirement Decision*

1 Introduction

The U.S. is in the middle of a significant demographic transition. The share of the population older than 65 as compared to the working age population (aged 20-64) is expected to double from 20.8% in 2000 to around 42% in 2075 (SSA (2004)). This will have enormous consequences for fiscal policy in the coming decades. Given current policies, the combined spending on medicare, medicaid and social security is projected to rise from 7.5% of GDP in 2000 to 18% of GDP in 2050 (CBO(2003)).¹ Thus, fiscal policy is unsustainable at current tax rates.

Three basic options for restoring fiscal sustainability are available to the U.S. government: (1) increasing taxes, (2) cutting replacement rates, and/or (3) increasing the eligibility age for social security benefits. How large are the required policy changes? To adequately answer this question, it is important to account for individual responses to policy changes. Retirement responses are of particular importance in this regard. Reforms to sustain fiscal policy can have at least two effects on retirement behavior. First, there might be a direct incentive effect. For instance, a reduction in benefits may delay retirement, due to a negative wealth effect. Second,

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¹ CBO's *Intermediate* spending scenario.

Table 4.1: Effect on the Average Retirement Age of a 20 Selected Studies

Study	Change in Retirement Age
Microstudies	
Krueger and Pischke (1992)	~ 0
Burtless (1986)	+ 2 months
French (2003)	+ 3 months
Macro studies	
This paper	+ 3 years

there may be important general equilibrium effects. For example, a reduction in social security benefits increases savings, thereby also reducing interest rates. This, in turn, may delay retirement via a negative wealth effect. This paper asks whether endogenous retirement responses are quantitatively important for fiscal policy reforms, accounting for both the direct incentive effect and the indirect general equilibrium effect.

Since the early 1980's, microeconomists have studied whether individuals respond to social security incentives. The general finding is that they do, but not to any considerable extent. For example, French (2003) shows that a 20% reduction in social security benefits delays retirement by three months. Other studies find effects that are equally small, see Table 4.1. Thus, retirement responses are modest and bring little hope that delayed retirement can contribute to restore fiscal sustainability.

The microeconomic literature naturally disregards any general equilibrium effects. The major finding of this paper is that general equilibrium effects are crucial determinants of retirement behavior and should be taken into account when considering social security reform. For instance, it is found that a 20% reduction in benefits results in a retirement delay of three years in the long run. The reason is that, in the experiment conducted here, reductions in benefits increase savings by both the government and the individual. This reduces the return to savings, i.e. a negative wealth effect, resulting in a general delay in retirement. Moreover, the paper finds that the general equilibrium effect on retirement of reducing the replacement rate dwarfs the direct incentive effect.

In addition, the paper makes a contribution by constructing three policies sustaining fiscal policy in the face of the aging population.² First, an immediate and universal reduction in benefits of 42% delays retirement by 3-4 years. The combination of reduced benefits and delayed retirement will be sufficient to set fiscal policy on a sustainable path (while keeping taxes unchanged). Second, an immediate and

² A fourth possibility is to increase immigration; see Storesletten (2000).

universal increase in the Full Retirement Age (FRA) to the age of 73 also sustains fiscal policy (while keeping taxes unchanged). The increase in FRA implies a delay in retirement of 8-9 years, and reduces the benefits paid to early retirees. Finally, an immediate 5.5 percentage point increase in the general tax rate also sustains fiscal policy. Interestingly, such a reform also implies a delay in retirement, due to a general feature of the sustainable policies considered here: the government builds up a net-asset position which reduces the interest rate, thereby causing a delay in retirement.

These results are found using a dynamic general equilibrium model with overlapping generations in the tradition of Auerbach and Kotlikoff (1987). This is a natural starting point for studying fiscal sustainability. The model assumes that individuals make optimal decisions on hours worked, consumption and savings over their life-cycle. A key feature is that individuals also make optimal choices about their retirement age, defined as the age at which they stop working and start receiving benefits. Previous literature has either assumed exogenous retirement or relied on simplifying assumptions, e.g. dramatic (and counterfactual) reductions in productivity around the age of 65.³ Moreover, the U.S. social security system is modelled in detail to study its incentive effects.

Individuals are assumed to be heterogenous in skills, which is important for a number of reasons. First, retirement behavior differs across skill groups. In particular, low-skilled individuals retire much earlier than high skilled ones, partly because productivity declines at old age are more pronounced for low-skilled individuals. Changes in fiscal policy may therefore have different effects on retirement behavior across skill groups. Second, future cohorts of retirees are, on average, better skilled. High-skilled individuals live longer and receive higher benefits. Thus, the increases in life expectancy raise fiscal expenditures, not only because of a higher fraction of old, but also because a higher fraction of old are high skilled.

The government is assumed to provide public consumption and redistribute transfers, including social security. Government expenditures are financed through taxation or by issuing public debt. Following Storesletten (2000), it is assumed that the government adheres to constant tax rules; that is, tax policies are changed once at most and are kept constant forever after under the requirement that fiscal policy is sustainable.

³ Eg. Kotlikoff, Smetters and Walliser (2001) and Nishiyama (2004). An exception is Sanchez Martín (2001) who studies a pension reform in Spain in 1997 and its impact on retirement behavior. However, in his model, labor supply is assumed to be exogenous on the extensive margin.

Table 4.2: Effect on the Payroll Tax of a Delay in the Retirement Age, Year 2100

Study	Retirement age		Tax Increase ¹	
	Baseline	Alternative	Baseline	Alternative
Attanasio et al (2005)	65	70	12.7	6.0
De Nardi et al (1999)	67	69	29.8	23.2
Kotlikoff et al (2002)	67	70	12.8	7.3

Note: 1. Percentage points relative to the year 2000.

The demographics of the economy evolve across time, which implies that savings, labor supply, government expenditures etc. will be changing as time goes by in accordance with the demographic developments.

The remainder of the paper proceeds as follows. Section 2 places this paper in the context of the previous literature. Section 3 outlines the model and section 4 discusses the calibration procedure. The results are discussed in section 5, while section 6 offers concluding remarks.

2 Related literature

The general issues in social security reform have been addressed in Diamond (1997, 2004), Feldstein and Liebman (2002) and Lindbeck and Persson (2003). This paper belongs to the class of dynamic general equilibrium models originating with Auerbach and Kotlikoff (1987). These models have been widely used to address issues on social security reform. Papers in this tradition include Conesa and Krueger (1999) and Hugget and Ventura (1997). However, most papers in this vein assume the population structure to be stationary. Some exceptions are Storesletten (2000), De Nardi, Imrohoroglu and Sargent (1998), Nishiyama (2003) and Kotlikoff, Smetters and Walliser (2002) who all study U.S. social security with aging populations. The current paper is a contribution to this literature.

The previous literature has quantified how much a delay in retirement can contribute to finance the shortfall in social security,⁴ see Table 4.2. The general finding is that the long-run required change in the tax rate can be cut in half by a general delay in retirement to the age of 70. However, most of the literature assumes retirement to be exogenous.

Kotlikoff et al (2002) and Nishiyama (2003) study models with endogenous retirement. However, they make two assumptions that effectively prevent a serious

⁴ The experiments generally assume the replacement rate to be constant and that claiming benefits is exogenously postponed.

analysis of retirement behavior. First, retirement is achieved by assuming an exogenous discrete drop in productivity at the time of retirement. In Kotlikoff et al (2002), for instance, productivity drops by 80% between ages 62 and 63. This is at odds with the empirical evidence. French (2003) carefully estimates productivity profiles for workers aged 30-80 and finds that productivity falls by around 4% a year between ages 60 and 70. In the current paper productivity will be assumed to decline at rates closer to those found by French (2003). Second, the social security rules are not fully modelled. As shown by Gruber and Wise (1998), Diamond and Gruber (1997), Coile and Gruber (2003) and Eisensee (2005), among others, social security incentives are important for retirement behavior. Therefore, the U.S. social security rules are modelled in detail for this paper.

The present paper assumes a constant tax rule, where taxes are changed once at most and kept constant thereafter. Debt adjusts accordingly to satisfy the government's budget constraint. This approach was advocated by Blanchard (1990) and explored by Storesletten (2000) in a dynamic general equilibrium setting. In contrast, the most commonly used assumption is that of constant debt rule: debt remains constant forever, while taxes adjust period by period to accommodate changes in expenditures. While *a priori*, there is no reason to choose one method over the other, the constant tax rule is attractive because it offers a one dimensional measure of the cost of sustaining current fiscal policy. In particular, it is easily shown that the tax rate implemented under constant tax rule is the ratio

$$\frac{\text{PDV (Expenditures)}}{\text{PDV (Tax Base)}}$$

where PDV indicates present discounted value. In addition, the assumption directly addresses the suggestion by some observers to build and maintain a trust fund, considerably larger than the current one, to save for the demographic developments (see e.g. Diamond (1997), Holzmann and Stiglitz (2001), Holzmann and Hinz (2005)). In fact, the model gives a precise estimate of how large the trust fund should be to render fiscal policy sustainable. Finally, the constant tax rule is attractive because it provides an answer to the question "what can I do today to sustain fiscal policy?". Constant debt rule, on the other hand, implicitly assumes that the government behaves myopically, setting taxes to balance only the budget of the current period.

As mentioned in the introduction, the paper is also related to the microeconomic literature on retirement and social security. Some recent papers include Rust and

Phelan (1997), French (2003), Coile and Gruber (2000), Diamond and Gruber (1997) and Gustman and Steinmeier (2002). French (2003), for instance, finds that the actuarial unfairness of social security is an important determinant of retirement behavior, while the level of benefits are not. The model developed here has similar properties.

The microeconomic literature naturally abstracts from general equilibrium effects, but these effects turn out to be important in the current paper. Coile and Gruber (2003) go part of the way by assessing the budgetary impact of social security reform in a steady state environment.⁵ They emphasize two effects of social security reform on public coffers. First, a "mechanical effect" whereby changing benefits or taxation lead to changes in revenue and expenditures *given* the retirement behavior. Second, a "behavioral effect" whereby individuals respond to changes in benefits and/or taxes, thereby inducing a change in revenues and expenditures. An important finding in their paper is that the mechanical effect is much larger than the behavioral effect in the United States, because the U.S. social security system is roughly actuarially fair. That is, a premium is given for delayed retirement, such that the present discounted value of benefits is almost the same, irrespective of the age of retirement. So, although individuals respond to social security reform by changing retirement behavior, this does not have any large budgetary impact.

Like Coile and Gruber (2003), the present paper finds the behavioral effect to be small and positive for reforms on the replacement rate and taxes, because U.S. social security is roughly actuarially fair. However, the behavioral effect is large and negative for reforms on the FRA. That is, increases in the FRA will be accompanied by delays in retirement. These changes in behavior will offset the mechanical effect, i.e. the reduction in benefits given the retirement age that results from increasing FRA.

3 The model

3.1 Population and heterogeneity

The economy is populated by individuals who live a maximum of I periods. Individuals differ in age, skills and, if an immigrant, the age at the time of immigration. The "type" of an individual is denoted (i, q, m) , where $i \in \{1, 2, \dots, I\}$ is age, q is

⁵ Interest rates and wages are taken as given, while taxes may respond to changes in benefits.

skill and m is the age at the time of immigration (natives have $m = 1$). Skills can take on three values: $q \in \{1, 2, 3\}$, corresponding to low-skilled, medium-skilled and high-skilled, respectively. Skill groups differ in terms of time spent in education, labor productivity, innate preference for leisure, ψ_q , and survival probabilities. Conditional on being alive at age $i - 1$, the probability of surviving to age i for a type (i, q, \cdot) individual is $s_{i,q}$.

In each period, new immigrants enter the economy at the constant rate φ of the total population in period $t - 1$. The age and skill composition of the immigrant population may differ from that of natives but, for simplicity, it is assumed that a type (a, b, \cdot) immigrant is identical in all respects to a type $(a, b, 1)$ native. Thus, the role of immigration is only to change the age and skill composition of the population. In the following, m will be suppressed whenever no ambiguity will accordingly arise.⁶

Following Lee (1974), Ríos-Rull (1992) and Storesletten (2000), the birth process is modelled as $\mu_{1,t} = \sum_i \phi_i \mu_{i,t} + z_t$, where $\mu_{i,t} = \sum_q \mu_{i,q,t}$ is the measure of age i individuals in period t , $\mu_{1,t}$ is the number of newborn natives at time t , $\mu_{i,q,t}$ is the measure of age i individuals in skill group q at time t , ϕ_i is the age-specific fertility rates averaged over time, and z_t is a deterministic process to be specified later. Children of immigrants are considered to be natives.

Individuals younger than age κ are defined as children. Upon entering adulthood at age κ individuals face a constant probability ν_q of entering skill group q .

3.2 Preferences, technology and markets

Individuals derive utility from a standard consumption good and leisure. Preferences are time separable. The instantaneous utility function takes the form $u(c, 1 - h)$, where c is current consumption and h is the time spent working in the market. The function $u(\cdot, \cdot)$ is increasing and strictly concave in both arguments. Children do not work and only consume the transfers provided by the government. Individuals do not care about their children and have no bequest motive.

A type q agent maximizes lifetime utility as given by

$$\max_{\{c_i, h_i\}, R} \sum_{i=\kappa}^I \beta^{i-\kappa} \pi_{i,q} u(c_i, 1 - h_i), \quad (4.1)$$

subject to the intertemporal budget constraints to be specified below. R is the retirement age defined as the age at which the individual chooses to stop working

⁶ See Storesletten (2000) for more realistic assumptions about immigrants.

($h_i = 0$) and starts collecting retirement benefits. This is a separate decision from the labor supply decision, since $h_i = 0$ is allowed without drawing retirement benefits. $\pi_{i,q}$ is the unconditional probability for an agent of type (i, q) of being alive at age i , defined as $\pi_{i,q} \equiv \prod_{j=\kappa}^i s_{j,q}$. Upon death, individuals get zero utility.

Individuals invest their assets in a perfect annuity market which pays a premium of $\frac{1}{s_{i,q}}$ on the gross interest rate.

Output in period t is given by a standard constant returns to scale production function $f(K_t, L_t)$ with aggregate labor, L_t , and capital, K_t , as inputs. Output is used for consumption and investment in new capital. Aggregate labor input in period t , L_t , is the sum of efficiency units supplied by individuals, i.e. $L_t = \sum_{i,q} e_{i,q,t} h_{i,q,t} \mu_{i,q,t}$ where $e_{i,q,t}$ is the number of labor efficiency units and $h_{i,q,t}$ is the time spent working by individuals of type (i, q) in period t . Representative firms rent labor and capital on the spot markets at a given wage rate, w_t , and gross rental rate, r_t , and the firm solves

$$\max_{K_t, L_t} \{f(K_t, L_t) - (r_t + \delta) K_t - w_t L_t\}$$

where δ is the depreciation rate of capital.

3.3 Government and social security

Government policy consists of a tax rule, a public spending rule, and a transfer rule that includes social security and other government transfer programs. The tax rule specifies a constant exogenous payroll tax rate τ_S levied on labor income below a threshold level, \hat{y} , and a constant endogenous tax rate τ on capital income, labor income and taxable OAI benefits.

Government consumption is given by a rule determining government purchases of goods and services as a function of population

$$G_t = \sum_i g_{i,0} \mu_{i,t}, \quad (4.2)$$

where $g_{i,0}$ is government consumption per agent of age i in period zero. Individuals derive no utility from government consumption. Since large components of government purchases of goods and services are age-dependent, it is important to condition public consumption on age. It could be argued that government consumption is a function of both age and retirement status. Such a link is somewhat ambiguous, however, so the simpler rule will be applied.

The government distributes social security benefits consisting of old age insurance (OAI), survivor's insurance (SI), disability insurance (DI), and Medicare (consisting of hospital insurance (HI) and supplementary medical insurance (SMI)).

At some age J^E individuals become eligible for OAI benefits. Only eligible individuals who are retired ($h = 0$) can receive OAI benefits. The individual's OAI transfer is a function $\Omega(d, R)$ of her (annualized) average indexed monthly earnings (AIME), d , and her age at retirement, R . AIME is a function $d(y)$ of the individual's earning history $y = \{y_\kappa, \dots, y_R\}$, where y_i are pre-tax earnings at age i . $\Omega(\cdot)$ is (weakly) increasing in R and concave in d . The concavity in d implies that benefits are regressive, while $\Omega_R(\cdot) \geq 0$ implies that a premium may be given for delayed retirement.

The remaining parts of social security - SI, DI and Medicare - are modelled as age-specific lump-sum transfers ξ_i . Thus, the model abstracts from any incentives these programs may have for the retirement decision.⁷ All other government transfer programs, such as unemployment insurance, welfare payments etc., are distributed as part of the age-specific lump-sum transfers ξ_i .

This specification obviously abstracts from possible substitutability between different government programs. It could, for instance, be argued that a downsizing of OAI benefits would increase enrollment in other government transfer programs, e.g. Supplementary Security Income (SSI), welfare payments and unemployment insurance.

The aggregate social security benefits and other government transfers in period t can be computed as

$$T_t = \sum_{i,q} (\mu_{i,q,t} (\xi_i + \Omega(d_{i,q,t}, R_{i,q,t}))), \quad (4.3)$$

where $d_{i,q,t}$ and $R_{i,q,t}$ are the AIME and the retirement age, respectively, of a type (i, q) individual in period t . Total tax revenues are given by

$$REV_t = \tau \left(w_t L_t + r_t K_t + \sum_{i,q} \mu_{i,q,t} \vartheta(d_{i,q,t}) \right) + \tau_S w_t \hat{L}_t, \quad (4.4)$$

where L_t and K_t are aggregate labor input and aggregate capital, respectively, and $\hat{L}_t = \sum_{i,q} \mu_{i,q,t} \min(e_{i,q,t} h_{i,q,t}, \hat{y}_t / w_t)$ is the part of labor input subject to the payroll

⁷ In particular, Rust and Phelan (1997) show that Medicare provides strong incentives for delayed retirement among some sub-groups, primarily low income workers with employer health insurance.

tax. The function $\vartheta(\cdot)$ returns the part of benefits that are subject to income taxation and is assumed to be a function of AIME, d .

Budget deficits are financed through increases in tax-exempt government bonds B_t . Bonds are held by private agents and evolve according to

$$B_{t+1} = B_t(1 + r_t(1 - \tau)) - REV_t + T_t + G_t, \quad (4.5)$$

where market clearing in the bonds market has been imposed, i.e. $r_t^B = r_t(1 - \tau)$.

3.4 Individuals' budget constraint and decision problem

The budget constraint of individual (i, q) at time t is

$$c_{i,q,t} + a_{i+1,q,t+1} \leq a_{i,q,t} \frac{1}{s_{i,q,t}} + m_{i,q,t}, \quad (4.6)$$

where $m_{i,q,t}$ denotes the after-tax income of the individual (i, q) at date t , $a_{i,q,t}$ denotes the asset holdings of (i, q) in period t , and $\frac{1}{s_{i,q,t}}$ captures the survivor's premium implied by the perfect annuity markets. Initial wealth is zero. Subsequently, an individual has four potential sources of income: labor earnings, interest income, lump-sum transfers and OAI benefits net of taxes. Thus,

$$m_{i,q,t} = \begin{cases} r_t(1 - \tau) a_{i,q,t} \frac{1}{s_{i,q,t}} + w_t e_{i,q} h_{i,q,t} (1 - \tau_S - \tau) + \xi_i & \text{if } \omega_{i,q,t} = 0 \\ r_t(1 - \tau) a_{i,q,t} \frac{1}{s_{i,q,t}} + \xi_i + \Omega(d_{i,q,t}, R_{i,q,t}) - \tau \vartheta(d_{i,q,t}) & \text{if } \omega_{i,q,t} = 1 \end{cases},$$

where $\omega_{i,q,t}$ takes on the value of 1 if individual (i, q) has chosen to receive OAI benefits at time t , and 0 otherwise.⁸ In other words, whenever $\omega_{i,q,t} = 1$, the individual is considered to be retired. The retirement age of an individual (i, q) at time t is defined as $R_{i,q,t} \equiv \min \{ \kappa \leq i \leq I \mid \omega_{i,q,t} = 1 \}$. The retirement decision will be assumed to be irreversible, i.e. that $\omega_{i,q,t} = 1$ for $i \geq R_{i,q,t}$. Irreversibility considerably simplifies the problem.⁹

⁸ An implicit assumption embodied in the budget constraint is that a beneficiary cannot work, i.e. $h\psi = 0$. Empirically, around 73% of the beneficiaries aged 65-69 did not work in 1989 (Friedberg, 1999). An equivalent assumption is that a 100% labor tax is levied on beneficiaries. At least two features of reality can motivate such an assumption: (1) in addition to federal and state taxes, the retirement earnings test levies a 33-50% marginal tax on labor supply on 62-64 year old beneficiaries who work and (2) the existence of technological constraints that prevent a low number of hours of work.

⁹ Relaxing this assumption will not substantially alter the results. In a steady state, individuals will choose to retire once and only once, even if they have the opportunity to reconsider their

The state of an individual can be summarized by the 4-tuple (a, y, i, q) . Given prices, policies, transfers and the initial conditions, a worker's value function, $v_t^{\mathcal{W}}$, is the solution to the following recursive problem

$$v_t^{\mathcal{W}}(a, y, i, q) = \max_{(a', c, h, \omega)} \{u(c, 1 - h) + \beta s_{i,q} [\omega v_{t+1}^{\mathcal{W}}(a', y', i + 1, q) + (1 - \omega) v_{t+1}^{\mathcal{R}}(a', y', i + 1, q)]\} \quad (4.7)$$

subject to

$$c + a' \leq (1 + r_t(1 - \tau)) a \frac{1}{s_{i,q}} + w_t e_{i,q} h (1 - \tau_S - \tau) + \xi_i, \quad \omega = 0 \quad (4.8)$$

$$\omega \in \{0, 1\} \quad (4.9)$$

$$a = 0, \quad i = \kappa \quad (4.10)$$

$$a' \geq 0, \quad i = I \quad (4.11)$$

$$y' = \left\{ \frac{w_{t+1}}{w_t} y, w_{t+1} e_{i,q} h \right\} \quad (4.12)$$

$$0 \leq h \leq 1 \quad (4.13)$$

and

$$v_t^x(a, y, I + 1, q) = 0, \quad x \in \{\mathcal{W}, \mathcal{R}\}. \quad (4.14)$$

A retiree solves the following recursion

$$v_t^{\mathcal{R}}(a, y, i, q) = \max_{(a', c)} \{u(c, 1) + \beta s_{i,q} [v_{t+1}^{\mathcal{R}}(a', y, i + 1, q)]\} \quad (4.15)$$

subject to

$$c + a' \leq (1 + r_t(1 - \tau)) a \frac{1}{s_{i,q}} + \xi_i + \Omega(d(y), R_q) - \tau \vartheta(d(y)), \quad \omega = 1 \quad (4.16)$$

and (4.10), (4.11) and (4.14).

choice. Following a reform, this is less straightforward. However, in an experiment where the replacement rate was reduced by 20%, it turned out that individuals who were retired at the time of the reform chose to remain retired.

3.5 Definition of equilibrium

This section describes the conditions jointly characterizing the equilibrium path of the economy following a reform at date $t = 0$.

Given initial conditions for debt B_0 , the error term of the fertility process z_0 , the distribution of assets a_0 , population distribution μ_0 , the sequence of past earnings $\left\{ \left\{ w_t e_{i,q} h_{i,q,t} \right\}_{i=\kappa}^I \right\}_{t=-I}^{-1}$, and government policies $\Psi = \left(\left\{ \xi_i, g_i \right\}_{i=0}^I, \tau_S, \Omega(\cdot), \vartheta(\cdot), d(\cdot) \right)$, an equilibrium is defined as a sequence $\left\{ w_t, r_t, L_t, K_t, A_t, B_t, \left\{ h_{i,q,t}, c_{i,q,t}, a_{i,q,t}, \omega_{i,q,t} \right\}_{i=\kappa}^I \right\}_{t=0}^{\infty}$, and a constant tax rate τ , such that the following holds

1. $\left\{ \left\{ h_{i,q,t}, c_{i,q,t}, a_{i,q,t}, \omega_{i,q,t} \right\}_{i=\kappa}^I \right\}_{t=0}^{\infty}$ solves the individuals' maximization problem, i.e. (4.7) and (4.15), given $\left\{ w_t, r_t \right\}_{t=0}^{\infty}$ and government policies (Ψ, τ) .

2. Factor markets clear

$$w_t = \frac{\partial f(K_t, L_t)}{\partial L_t} \quad t = 0, 1, \dots$$

$$r_t = \frac{\partial f(K_t, L_t)}{\partial K_t} - \delta \quad t = 0, 1, \dots$$

3. The goods market clears every period

$$f(K_t, L_t) + (1 - \delta) K_t + A_t^{im} = K_{t+1} + G_t + \sum_{i,q} \mu_{i,q,t} c_{i,q,t} \quad t = 0, 1, \dots$$

where G_t satisfies (4.2) and $A_t^{im} = \sum_{i,q,m} \mu_{i,q,m,t} a_{i,q,t} \frac{(1+r_t(1-\tau))}{s_{i,q,t}}$ are the assets brought into the economy by immigrants arriving in period t .

4. The tax rate τ solves the government's feasibility constraint

$$B_0 = \sum_{t=0}^{\infty} \frac{REV_t - G_t - T_t}{\prod_{j=0}^t (1 + r_j)} \quad (4.17)$$

where $REV_t(\tau)$ is given by (4.4), G_t by (4.2) and T_t by (4.3).

5. The sequence of government debt, $\{B_t\}_{t=0}^{\infty}$, is generated by the government's short-term budget constraint (4.5).
6. The market for savings clears

$$K_t = A_t - B_t \quad t = 0, 1, \dots$$

Table 4.3: Calibration

	Parameter	Value
Population	κ	20
	I	100
	(ρ_1, ρ_2)	(1.28, -0.65)
	φ	0.32%
	(ν_l, ν_m, ν_h)	(0.418, 0.267, 0.315)
	Mortality	SSA projection/NCHS skill factor
	Immigrant flow distr.	1998-2002 Immigrant distribution
Preferences	$(\psi_l, \psi_m, \psi_h, \gamma)$	(4.6, 3.5, 1.8, 4)
	σ	2
	β	1.0012
Technology	α	0.4
	δ	0.09
Government	$(g_{0-24}, g_{25-64}, g_{65+})$	(18.3%, 10.1%, 17.2%) of Y_0
	Medicare	2000 level
	Other Transfers	2000 level
	Social Security	U.S. system in 2000
	τ_S	15.3%
	Marginal tax on benefits	$\tau \times 45\%$
Initial Conditions	B/Y	47.4%
	K/Y	2.77
	Population distr.	2000 Census

where $A_t = \sum \mu_{i,q,t} a_{i,q,t}$.

7. The population sequence $\left\{ \left\{ \mu_{i,q,t} \right\}_{i=\kappa}^I \right\}_{t=1}^{\infty}$ is generated by μ_0, z_0 and the mortality, fertility and immigration processes as specified in (4.18) below.

4 Calibration

This section describe the calibration procedure. For an overview of calibration choices see Table 4.3.

4.1 Skill groups

The skill groups are defined as follows

- Low skilled: High school degree or less.
- Medium skilled: More than a high school degree, but less than a bachelor's degree.

- High skilled: Bachelor's degree or higher.

This division was chosen to ensure a large measure of individuals in each skill group and yet preserve some heterogeneity. Thus, in the year 2000, their respective shares of the population were 45.9%, 25.1% and 29% (Current Population Survey 2000, March Supplement).

4.2 Demographic Process

The demographic process for the population can be described by the following system¹⁰

$$\mu_t = \Gamma_t \mu_{t-1}, \quad (4.18)$$

where μ_t is a $(2 \cdot 3 \cdot I + 2) \times 1$ - vector containing the measure of individuals at different ages (I), skill groups (high, medium, low) and groups of origin (natives, immigrants) at time t , as well as the lagged fertility shocks. Γ_t is the $(2 \cdot 3 \cdot I + 2) \times (2 \cdot 3 \cdot I + 2)$ projection matrix containing the survival probabilities and fertility rates of individual cohorts at time t , the skill probabilities, the net-immigration rate, and the error process of fertility.

In the following, the calibration of $\{\Gamma_t\}_{t=0}^{\infty}$ and μ_0 will be explained. Given the calibration, the Perron-Frobenius theorem ensures convergence to a stationary population distribution with a constant population growth rate.

4.2.1 Initial population distribution

The initial age and skill distribution for natives and immigrants, μ_0 , is estimated from the U.S. Decennial Census 2000 and the Current Population Survey 2001 (March Supplement).

4.2.2 Fertility rates

Following Lee (1974), Ríos-Rull (1992) and Storesletten (2000), fertility rates are derived using the specification

$$\mu_{1,t} = \sum \phi_i \mu_{i,t} + z_t$$

¹⁰ See Caswell (1999) for an excellent exposition of matrix population models.

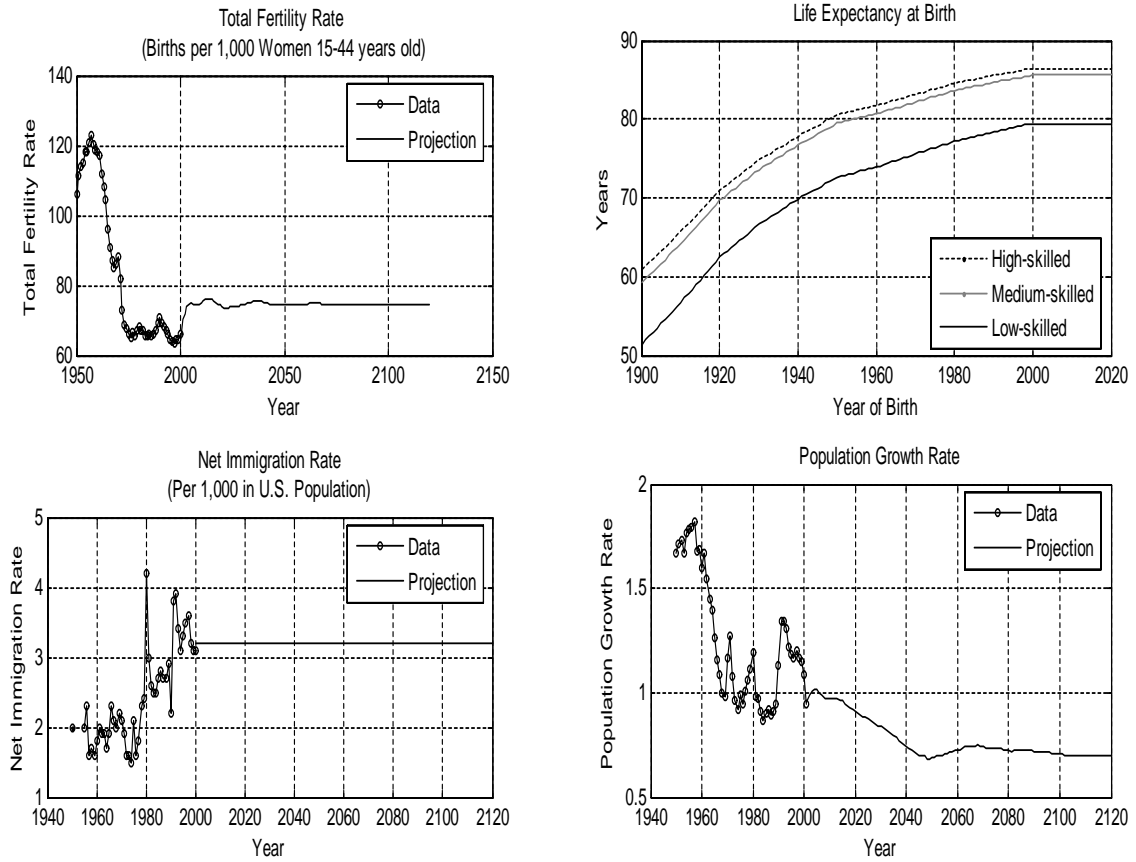


Figure 4.1: Demographic Transition, 1950-2120 – Total Fertility Rate, Life Expectancy, Net Immigration Rate and Population Growth Rate

where $\mu_{i,t}$ is the measure of age i agents in period t and ϕ_i is the fertility rate of the average woman at age i , and z_t is an error term. The fertility rate ϕ_i is estimated by averaging over the 1960-2002 time period (National Center for Health Statistics (2003) and Bureau of the Census, various years). This implies a final total fertility rate of 2.20, compared with 2.18 in the middle projections of the U.S. Bureau of the Census (2000) and 1.95 for the intermediate projections of the Social Security Administration (2003). Storesletten (2000) finds that for the U.S., the error term z_t in the above process can be approximated by an AR(2) process, $z_t = \rho_1 z_{t-1} + \rho_2 z_{t-2} + \varepsilon_t$. His estimates, $\rho_1 = 1.28$ and $\rho_2 = -0.65$, are used here. In the model, z_t will be assumed to follow a deterministic version of the estimated AR(2) process, with the 1999 and 2000 values as a starting point, while shutting down all future shocks. The process implies that z_t is close to zero after about twenty periods. The implied fertility rates are plotted in Panel 1 of Figure 4.1.

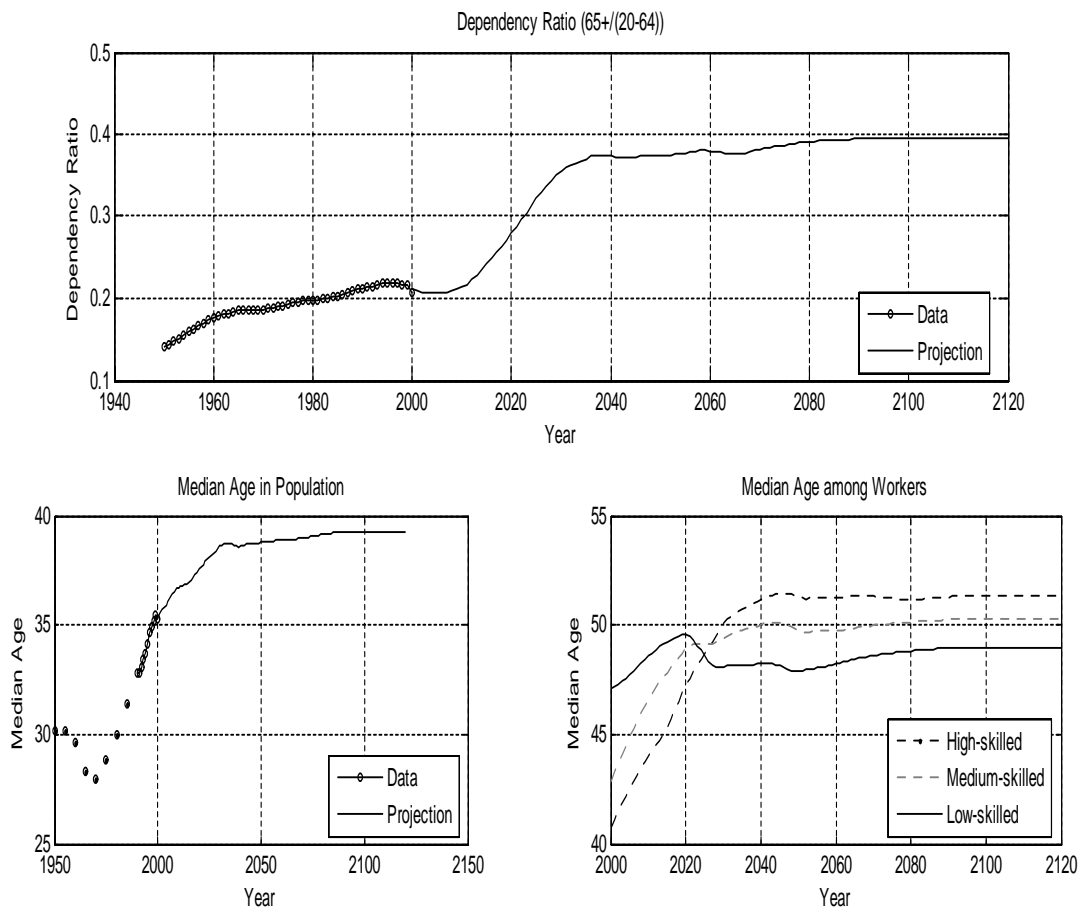


Figure 4.2: Demographic Transition, 1950-2120 – Dependency Ratio and Median Age.

Table 4.4: Mortality Index by Age and Skill Group

Skill group	Age				
	20-34	35-44	45-54	55-64	65+
Low	1.59	1.48	1.37	1.26	1.15
Medium	0.64	0.65	0.67	0.68	0.69
High	0.37	0.44	0.52	0.59	0.67

Source: Author's estimate based on NCHS(1998), CPS 1999 March Supplement. Note: The value for the age group 20-24 is assumed to be the same as for the age group 25-34

4.2.3 Mortality rates

Average mortality rates are from the SSA (2003a).¹¹ SSA (2003a) provides historical and projected mortality rates for cohorts born 1900 until 2000 at ten-year intervals. Mortality rates for cohorts born in between have been obtained by linear interpolation. Cohorts born after the year 2000 are assumed to face the same mortality rates as the 2000 cohort. SSA (2003a) only provides mortality rates for males and females separately. To compute mortality rates for males and females together, it is assumed that the sex ratio (males/females) for newborns is 1.048 (the year 2000 value) for all cohorts.

Several studies document that mortality rates differ widely across educational groups (see e.g. Elo and Preston (1996)). Thus, age and educational dependent mortality rates are computed as

$$(1 - s_{i,q}) = m_{i,q} (1 - s_i) \quad \forall i, q$$

where $(1 - s_{i,q})$ is the probability of dying between age $i - 1$ and i for an individual of type q . The parameter $m_{i,q}$ is a factor that multiplies the average mortality rate to get the educational-cohort specific mortality rate. The values are displayed in Table 4.4. Note that $m_{i,q}$ is assumed to be constant over time.

The implied life expectancy at birth for each skill group is depicted in Figure 4.1, Panel 2. For the cohort born after the year 2000, life expectancy at birth is 79.5, 85.6 and 86.4 years, respectively (low/medium/high skilled). In comparison, the life expectancy implied by the year 2000 mortality tables is 74.3, 81.0 and 82.0, respectively.

¹¹ Data was kindly provided by Felicitie C. Bell, Social Security Administration.

4.2.4 Skill process

Upon turning twenty the individual faces an exogenous probability, ν_q , of becoming high, medium or low skilled. The probabilities are set at $\nu_q = \{0.418, 0.267, 0.315\}$, respectively. These figures have been imputed from the skill distribution of 30-34 year olds in the population in 2002 (respectively 41.3, 27.0 and 31.7 %, respectively) together with the actual mortality process experienced by this cohort (properly adjusted for skill differences). Children of immigrants follow the same process. An implicit assumption is that the post-WWII increase in educational attainment comes to a halt. This is consistent with evidence in Day and Bauman (2000).

4.2.5 Immigration

The annual net flow of immigrants (immigration less return migration) is set at $\varphi = 0.32$ percent of the total population. This is derived in the following way: the stock of immigrants in a given year is assumed to follow the process $IM_{t+1} = \tilde{\varphi}P_t + (1-\eta)IM_t$. Here IM_t is the stock of immigrants at time t , P_t is the total population size at time t , η is the fraction of immigrants returning to their home-country and $\tilde{\varphi}$ is the immigration rate. Suppose that net-immigration can be described in terms of total population only, so that $\varphi P_t = \tilde{\varphi}P_t - \eta IM_t$. Then, the net-immigration rate, φ , can be determined as $\varphi P_t + IM_t = \tilde{\varphi}P_t + (1-\eta)IM_t \Rightarrow \varphi = \tilde{\varphi} - \eta \frac{IM_t}{P_t}$. The annual inflow of legal immigrants, $\tilde{\varphi}$, was 0.38 percent of the total population in 2002 (INS (2003)). Warren and Peck (1980) find that 5.2 percent of the immigrants in 1960 had emigrated from the U.S. by April 1, 1970. Thus, the equation $(1-\eta)^{10} = 1 - 0.052$ pins down the annualized return migration rate, $\eta = 0.53$ percent. The stock of immigrants was 11.5 percent of the population in 2002. Together, this implies that the net flow of immigrants is $\varphi = 0.32$ percent of the population. Panel 4 of Figure 4.1 plots the net-immigration rate in 1950-2120.

Immigrant flows are assumed to follow the age and skill distribution of immigrants arriving between 1998-2002 (CPS 2002, March Supplement).

4.2.6 Demographic Transition

The assumptions described above result in a demographic transition ending in 2100.¹² The population growth rate drops from 1.1% in 2000 to 0.7% eventually

¹² Stationarity in the population distribution is imposed in year 2100. The demographic transition in general takes longer. However, subsequent results are not sensitive to this assumption.

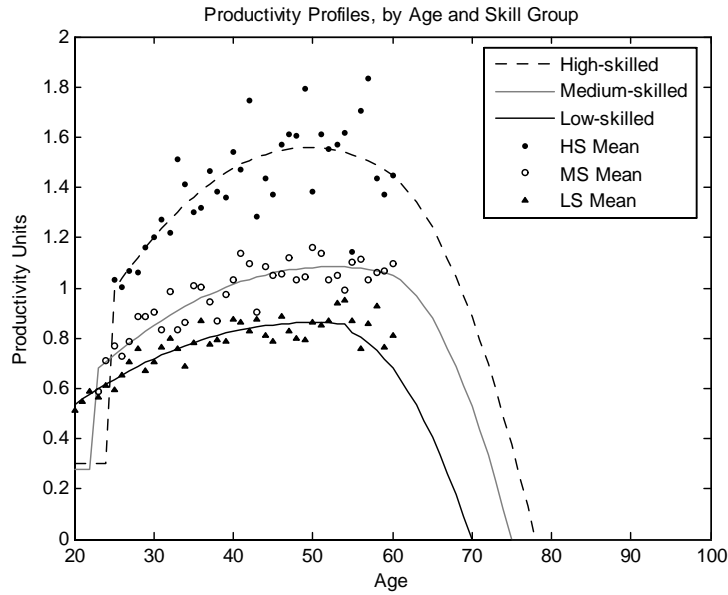


Figure 4.3: Productivity Profile, by Age and Skill Group

(see Panel 4 of Figure 4.1). The dependency ratio calculated as the population aged above 65 to the population aged 20-64 rises from 21% in the year 2000 to 40% in 2100 (Panel 1, Figure 4.2). Moreover, the median age in the population increases from 35 in the year 2000 to 39 in 2100 (Panel 2, Figure 4.2). The increase in the median age is primarily driven by increases in the median age among high- and medium-skilled (Panel 3, Figure 4.2). The median age among adults rises from 47 in the year 2000 to 49 in 2100 for low-skilled, and from 41 to 51 for high-skilled.

4.3 Productivity

Productivity profiles, $\{e_{i,q}\}_{i=\kappa}^I$, are piecewise polynomials in age. They are divided into three segments according to stages in the life cycle: education, prime-age, and late-life.

4.3.1 Education

Based on data from CPS (2002) on educational attainment by age, it will be assumed that low, medium and high skilled are enrolled in post-secondary education during 0, 3 and 5 years of their adult life, respectively. While their working life thus starts at the age of 20, 23 and 25, respectively, they will be allowed to work part-time during their educational period. In particular, the National Center for Educational Statistics (1996) report that full-time undergraduate students work on average 23

hours per week. Therefore, market productivity for high and medium skilled during post-secondary education is calibrated such that average work equals 23 hours per week in the initial period of the model.

4.3.2 Prime-age

Productivity profiles during prime age are estimated using a subset of the CPS 1999, March Supplement. The subset consists of 20-60 year olds who are in the labor force, working full time and have reported positive usual labor earnings. Productivity profiles are computed for three skill groups separately, using a method similar to Hansen (1986).

4.3.3 Late-life

Especially important for the question addressed in this paper is the productivity profile say, past the age of 60. For this age group, the self-selection problems are presumably formidable. Moreover, they are compounded by the small sample sizes at high ages.

For this reason, a very crude method is devised to approximate the productivity profile of the elderly. A quadratic function is interpolated between the productivity at the age of 55 and zero at the median age of transition into disability. The median age of transition into disability, estimated using data from the Survey of Income and Program Participation (1996), are age 70, 75 and 78 for low-, medium- and high-skilled, respectively. The calibration implies that between ages 60 and 70, productivity declines at an annual average of 8, 19, and 17 percent for the low, medium and high skilled, respectively. This is higher than the 4% implied by the productivity profile estimated by French (2003) and can therefore be viewed as a conservative benchmark.

4.4 Preferences and Technology

Preferences are standard from the microeconomic literature on labor supply. The instantaneous utility of an agent is additively separable in consumption and leisure

$$u_q(c_t, 1 - h_t) = \frac{c_t^{1-\sigma}}{1-\sigma} + \psi_q \frac{(1 - h_t)^{1-\gamma}}{1-\gamma} \quad (4.19)$$

This functional form has the attractive property that both labor supply and the elasticity of labor supply can be calibrated in accordance with empirical es-

timates.^{13,14} The set of parameters $(\psi_l, \psi_m, \psi_h, \gamma) = (4.6, 3.5, 1.8, 4.0)$ together implies that the average labor supply for 25-60 year olds is 27.8, 31.6 and 35.8 hours/week for low, medium and high skilled, respectively, i.e. the same as in 1999 (CPS 1999, March Supplement). Moreover, the implied Frisch labor supply elasticity, $\epsilon_F = \frac{dh}{dw} \Big|_{u_c} \frac{w}{h} = \frac{1}{\gamma} \frac{1-h}{h}$, is 0.65, 0.54, and 0.45, respectively.¹⁵ These figures are at the middle of the empirical estimates, which typically lie in the range $[0, 1.5]$. The risk aversion parameter σ is set at 2. The production function is standard Cobb-Douglas with a capital share equal to 0.4. Prescott (2004) reports a K/Y ratio of 2.77 and McGrattan and Prescott (2003) reports an after-tax interest rate of 4%. These targets are achieved in this model by setting $\beta = 1.0012$ and the depreciation rate, δ , at 9%.

In the initial period, the transition into retirement occurs at ages 62, 65 and 66 for low, medium and high skilled, respectively. In comparison, the empirical retirement ages are around 62, 64 and 65; see Figure 4.4.¹⁶ Thus, the model does a good job in replicating retirement behavior. It should be emphasized that the parameters have not been set to achieve a specific retirement age.

4.5 Government

A *status quo* economy is used for calibrating the parameters of the government, where the current social security policies are pursued and the government is assumed to maintain a fixed debt-to-output ratio for the indefinite future, i.e. the government adheres to a constant debt rule. The details of the procedure are explained in the

¹³ A Cobb-Douglas specification in consumption and leisure would imply a too high a Frisch elasticity for realistic hours of work.

¹⁴ A utility function often used in the macroeconomic literature on labor supply is $u_{2q} = u_{2q}(c, h) = u(c) - \rho_q \frac{h^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}$. This function has the attractive feature that the Frisch elasticity is constant and equal to γ . However, it does not lend itself well to the study of the retirement decision. First, the marginal disutility of work at the extensive margin is lower in u_2 than in $u_{1q} = u_{1q}(c, h) = u(c) + \psi_q \frac{(1-h)^{1-\gamma}}{1-\gamma}$. To see this, note that $\frac{du_{2q}}{dh} \Big|_{h=0} = 0 > \frac{du_{1q}}{dh} \Big|_{h=0} = -\psi_q$, since $\psi_q > 0$. In itself, this is not a sufficient condition to choose u_{1q} over u_{2q} . However, it turns out that for realistic parameter values, u_{2q} implies that individuals will choose to retire much later than what is observed in the data. Second, the model allows for heterogeneity in the intrinsic devotion to work ψ_q . As can be seen from $\frac{du_{iq}}{dh} \Big|_{h=0}$, only u_{1q} has the implication that the marginal value of retirement increases in ψ_q .

¹⁵ To compute ϵ_F hours of work, h is taken to be the mean hours of work between ages 25 and 60.

¹⁶ Computed as the age at which at least 50 percent of the skill group has left the labor force (CPS, 2002 March supplement). This is a very simple way of computing retirement ages. More advanced methods can be used. However, these methods have their share of methodological problems.

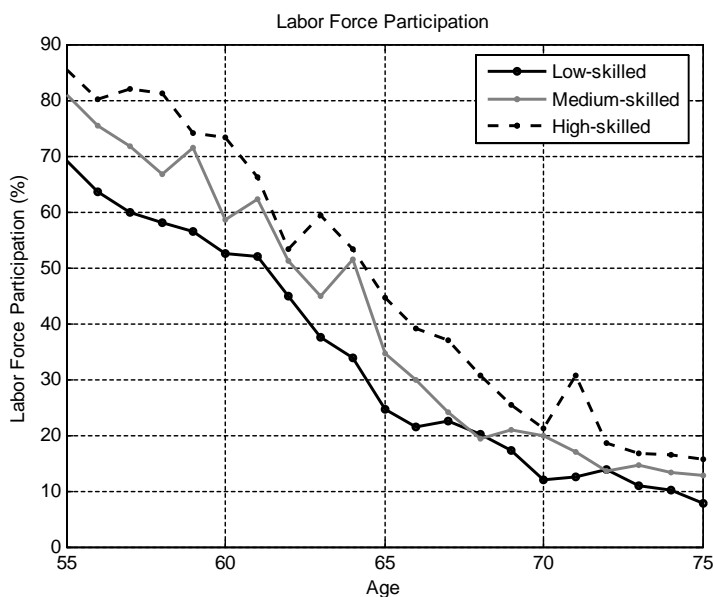


Figure 4.4: Labor Force Participation Rate, By Age and Skill Group

Appendix.

Following Storesletten (2000), government consumption is computed as $G_t = \sum_{i,q} g_{i,0} \mu_{i,t}$ where $g_{i,0}$ is government purchases of goods and services for an individual of age i in the base year. Using the Auerbach et al (1989) estimates of age-specific shares in non Social Security government expenditures, the levels of g_i are computed to 18.3%, 10.1% and 17.2% of GNP per capita for age groups 0-24, 25-64, and 65+, respectively. This implies that government consumption is 13.4% of GNP in the first period of the status-quo economy, the same as in 2000 (BEA (2005)).¹⁷

All workers are assumed to be enrolled in social security. The Old Age Insurance (OAI) formula is a function $\Omega(\cdot)$ of AIME. AIME is computed as the average of the $\varsigma = 35$ best earning years of worklife and is indexed to average wage growth in the economy. The function $\Omega(d, \cdot)$ is piecewise linear with three bend points. Using data from SSA and the US census, the bend points are set at 19%, 114% and 225% percent of average gross labor earnings in the economy.¹⁸ The replacement rates (i.e. the slopes of $\Omega(d, \cdot)$) between the bend points are 90%, 32%, 15%, and 0%. For

¹⁷ Computed as consumption expenditures less current transfer receipts (primarily fines, fees and donations) .

¹⁸ Gross labor earnings were \$33, 419 in 2000 (U.S. Census Bureau, PINC-10) and the annualized breakpoints were \$6, 372, \$38, 424, and \$76, 200 in the same year (SSA (2004)).

later use, define the slopes of $\Omega(d, \cdot)$ as

$$\Lambda \equiv \begin{cases} 0.9 & d \in (0, 0.19\bar{y}) \\ 0.32 & d \in (0.19\bar{y}, 1.14\bar{y}) \\ 0.15 & d \in (1.14\bar{y}, 2.25\bar{y}) \\ 0 & d > 2.25\bar{y} \end{cases}, \quad (4.20)$$

where \bar{y} is mean earnings. The Full Retirement Age (FRA) is set at 65. However, workers are eligible for OAI benefits at reduced rates from the age of 62. Benefits are reduced by 2/30 for each year before FRA the individual chooses to retire (reduction for early retirement, RER). Moreover, if a worker chooses to delay retirement beyond the age of 65, the worker will get a delayed retirement credit (DRC) of 6% per year until the age of 70. This implies that the monthly OAI benefits received by a retiree are \$796, \$1,226 and \$1,633 for low, medium and high skilled, respectively. The average monthly retirement benefits in the economy are \$992 per retiree.¹⁹

Benefits from survivor's insurance (SI), disability insurance (DI), hospital insurance (HI), and the subsidy part of supplementary medical insurance (SMI) are modelled as age-dependent lump-sum transfers. Storesletten (2000) computed these transfers as a function of age, and his estimates are used here. This implies that the total transfers to SI, DI, HI and SMI are 2.6% of GNP, the same as in 2000.²⁰ Thus, total old-age related transfers stand at 7.7% of GNP.

All other transfers at the federal, state and local level (welfare, unemployment benefits, subsidies, etc.), which stood at 4.9% of GNP in 2000, are evenly distributed across all adults as part of the transfer. Thus, in the initial period of the debt-constrained economy, total transfers (incl. social security) are 12.6% of GNP.

The initial debt is set at 47.4 of GNP, equal to the net financial liabilities of the US government at the end of 1999 (OECD (2004), BEA(2005)).

The payroll tax, τ_S , is set to 15.3%, equal to the actual combined medicare and OASDI payroll tax (employer and employee). The payroll tax is only levied on income below a threshold level. Using data from SSA and the US census, this threshold is set at 225% percent of the average gross labor earnings in the economy.²¹

¹⁹ The average OAI benefit for a newly retired individual was \$880 in 2000 (SSA (2001)).

²⁰ Computed as expenditure on SI, HI, SMI and DI net of premiums paid for HI and SMI (Board of Trustees, 2002).

²¹ Since the attention is restricted to three large groups, none of the individuals will, in practice, have an income above the threshold level.

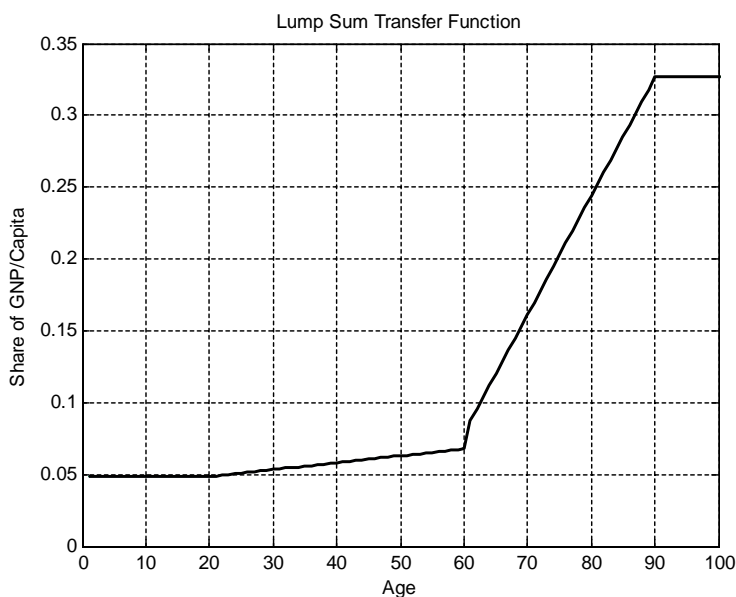


Figure 4.5: Lump Sum Transfer Function

The benefit taxation function, $\vartheta(\cdot)$, levies a marginal tax on benefits at 0 or 45% of the income tax rate τ . In the US tax code, the tax rate is a function of benefits and other income. I abstract from this by letting $\vartheta(\cdot)$ depend on AIME only. This is without substantial loss of generality, since AIME is highly correlated with both benefits and non-transfer income received during retirement (see French (2003)). The tax is levied on AIME between 114% and 225% of average gross earnings in the economy. This is equivalent to the third bracket in $\Omega(\cdot)$. The marginal tax is calibrated to 45%, such that the revenues from the tax equal 0.1 % of GNP, the same as in 2000 (SSA (2001a)).

Under the *status quo* policy, the government sets taxes to balance (4.17) under the assumption that the debt-output ratio remains at 47.4% forever. Given expenditures, other tax policies and initial debt, the implied tax rate is then $\tau = 23.39\%$ and the associated tax revenue is 28.2 percent of output.^{22, 23}

²² The average tax revenue 1998-2002 was 28.3 percent of GNP (BEA, 2005). It is computed as current tax receipts plus contributions to government social insurance, less taxes from the rest of world. In 2000, the tax revenues stood at 29.4 percent of GNP and the surplus was 2.3 percent of GNP. In the model, this would be achieved by an increase in τ of 1.1 points.

²³ The status quo economy would imply a gradual increase in taxes to accommodate the increasing share of retirees. In the final steady state, the tax rate would stand at around 33%.

5 Results

This section considers three sustainable fiscal reforms: a Tax Reform (TR), a Replacement Rate Reform (RR) and a reform of the Full Retirement Age (FR).

5.1 Tax reform (TR)

In the tax reform economy, the current social security policies are pursued and the budget is balanced through an increase in the general tax rate, τ .

The equilibrium income tax rate in this economy is $\tau^* = 28.9\%$, i.e. 5.5 points higher than the initial tax rate of 23.4%. Thus, a once and for all increase in taxes of 5.5 percentage points would preempt the need for any future fiscal reform associated with the demographic transition.²⁴ The economic transition of the Tax Reform economy is described in Figure 4.6. The increase in the general tax rate implies that the government runs budget surpluses from the first period and runs down debt (Panel 1). Eventually, the government holds a net-debt of -128% of GNP and the proceeds go to financing of government expenditures.²⁵ Thus, the government becomes a net-lender vis-a-vis the public. The reduction in government net-debt results in falling interest rates (see Panel 2) and an equiproportional increase in the wage rate (Panel 3). In addition, the demographic changes imply an increase in the K/L ratio, which also contribute to the decline [increase] in interest rates [wages]. Moreover, the hike in the general tax rate reduces the after-tax return, shifting the graph of the interest rate vertically down. However, it also reduces saving incentives, which tend to increase the interest rate.

It is interesting to note the response in labor supply following the reform. In particular, labor supply measured in efficiency hours per capita drops by around 5% upon the implementation of the reform (Panel 5). This is a result of the permanent increase in wages, which increases demand for leisure, (i) due to a wealth effect and (ii) since the income effect dominates the substitution effect ($\sigma > 1$). The hump-shaped developments 2001-2030 in efficiency hours per capita arise because the

²⁴ According to SSA's (2005a) projections, the actuarial imbalance for an infinite horizon corresponds to a 3.5 percentage point increase in the payroll tax. However, the SSA (2005a) figures are not directly comparable, because (1) the model used here takes a broader view of public finances by eg. also including public consumption, (2) the model accounts for endogenous responses to changes in policy, and (3) the tax base is larger in the model by also including capital.

²⁵ One possible interpretation is that the government expands the Trust Fund, which eventually constitutes $TF_T = (B_T - B_0 + TF_{2000})/GNP_T \approx 185\%$ of GNP, or roughly 20 times its size in 2000 (at the end of 2000, the OASI Trust Fund stood at $TF_{2000} = \$931$ billion or 9.4% of GNP).

Table 4.5: Tax Reform - Decomposition of the change in the retirement age

	Low skilled	Medium skilled	High skilled
Initial Period	62	65	66
Δw	62	65	66
$\Delta w + \Delta r$	64	66	68
$\Delta r + \Delta w + \Delta s$	65	67	69
$\Delta r + \Delta w + \Delta s + \Delta \tau$	65	67	69

baby-boom cohort enters its years of peak productivity (age 50-60), before eventually retiring.

The new policy implies a delay in retirement from the first day of implementation, see Figure 4.7. Eventually, low, medium and high skilled retire at ages 65, 67 and 69, respectively. Table 4.5 decomposes the change in the retirement age. From the individual's perspective, four objects change between the initial period and the final steady state: wages, interest rates, survival probabilities and the tax rate. The table decomposes the change in the retirement age into these four parts. Thus, the first row reports the optimal retirement age under the prices, survival probabilities and taxes prevailing in the year 2000, before the tax reform, i.e. (w_0, r_0, s_0, τ_0) . The second row displays the optimal retirement age assuming that wages have changed to their new steady-state level, i.e. $(w_{SS}, r_0, s_0, \tau_0)$. The third row shows retirement ages when wages *and* interest rates have changed, i.e. $(w_{SS}, r_{SS}, s_0, \tau_0)$, etc.

The increase in wages tends to increase the demand for leisure and retirement, since the income effect is larger than the substitution effect ($\sigma > 1$).²⁶ However, this effect is small on the retirement margin and is not reflected in Table 4.5. Moreover, it is dominated by three other forces – all of them reducing the returns to savings. They give rise to a negative wealth effect resulting in delayed retirement. First, the reduction in interest rate depresses the return to retirement income, which is the primary cause of the retirement delay. Second, the rising survival probabilities effectively reduce the returns to annuities. Finally, the increase in the general tax rate, τ , (i) reduces the returns to savings and (ii) reduces after-tax earnings. Both forces tend to delay retirement.²⁷ However, the effect is not sufficiently large to be reflected in Table 4.5. Thus, it is first and foremost the change in interest rates and survival probabilities that drives the change in retirement behavior.

²⁶ The model uses discrete time with one-year periods. Therefore, marginal changes in the demand for retirement may not be reflected as actual changes in the age of retirement (in integer years).

²⁷ Recall that the income effect dominates. Thus, (ii) will result in increased labor supply.

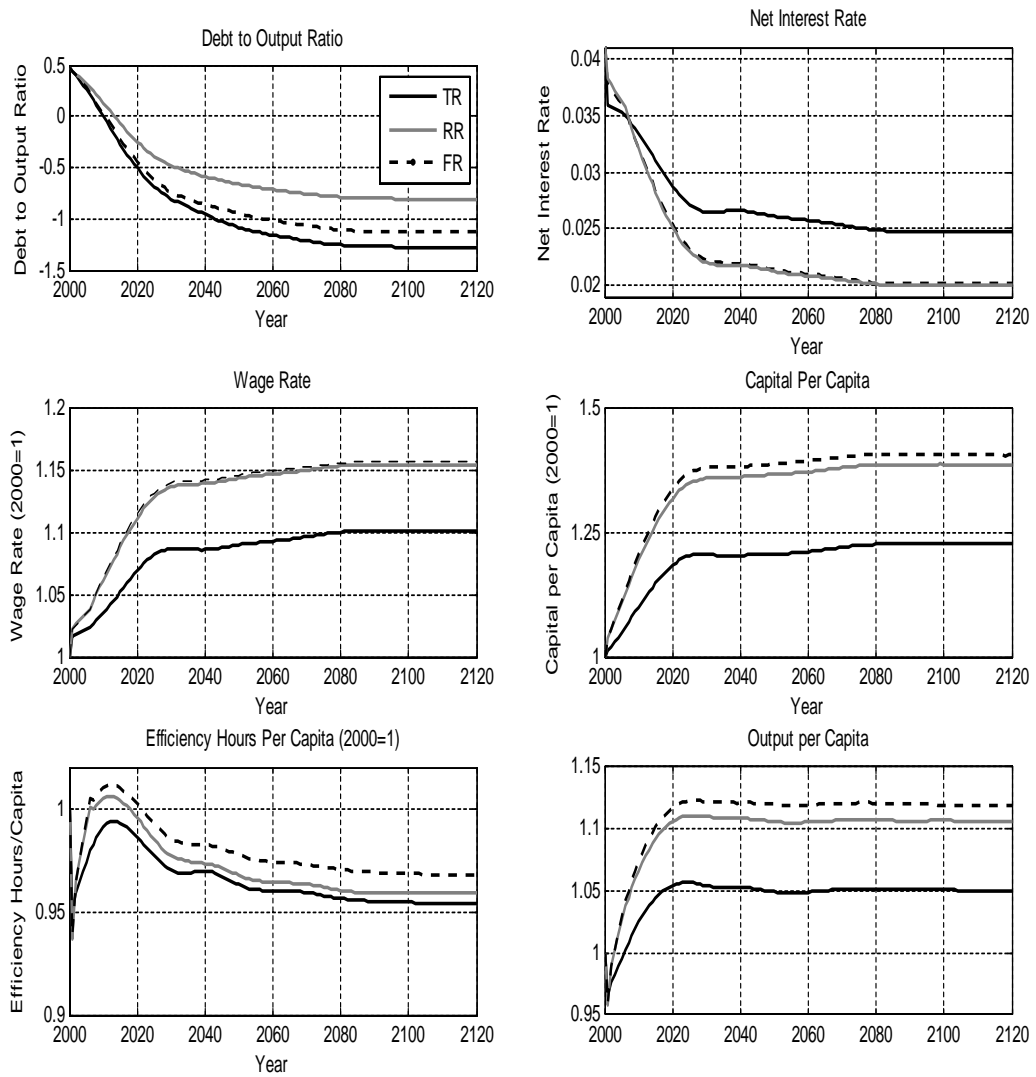


Figure 4.6: Economic Transition, 2000-2120, by Reform – Debt, Interest Rate, Wage Rate, Capital/Capita, Efficiency Hours/Capita, Output/Capita.

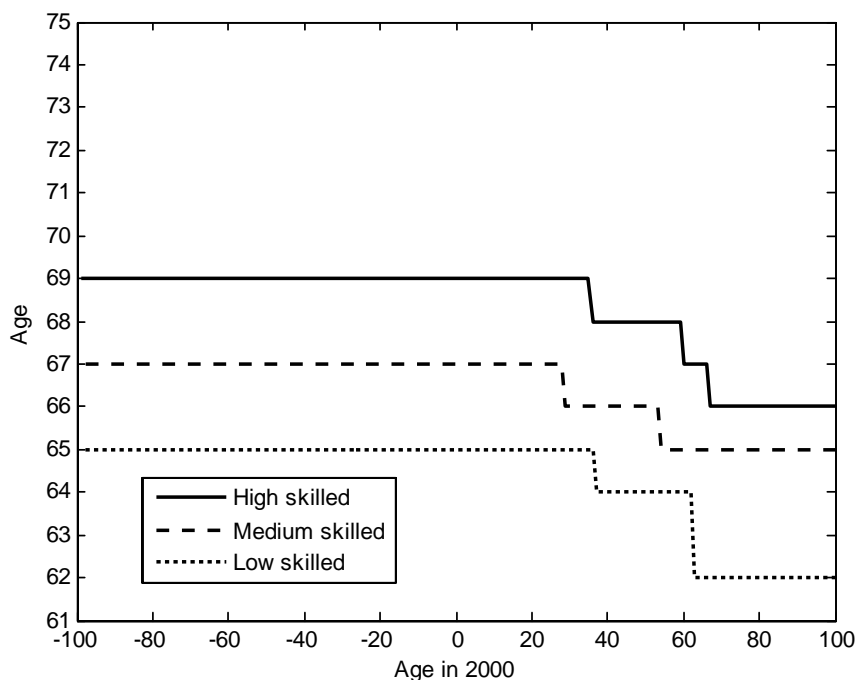


Figure 4.7: Tax Reform: Retirement Age by Age in Year 2000.

Notice that retirement behavior responds slowly. There can be three reasons for the gradual response: (1) prices change slowly, (2) survival probabilities change slowly, or (3) it takes time for individuals to re-adjust wealth to new economic circumstances. To further investigate why the retirement age responds gradually, consider the following experiment: assume that prices/survival probabilities immediately adjust to their steady-state level. Next, re-compute the optimal retirement response. Figure 4.8 reports the results for the high-skilled (the results are similar for other groups). The full black line indicates the retirement response when both prices and survival probabilities immediately jump to their new steady-state level. Then, retirement behavior immediately adjusts. The dotted line represents the retirement response when prices immediately jump to the new steady-state, while survival probabilities change gradually. The punctuated line represents the retirement response when prices immediately change to the new steady state, while survival probabilities change gradually. Clearly, the gradual response of retirement is mainly driven by the gradual changes in survival rates, but also by the sluggish changes in prices.

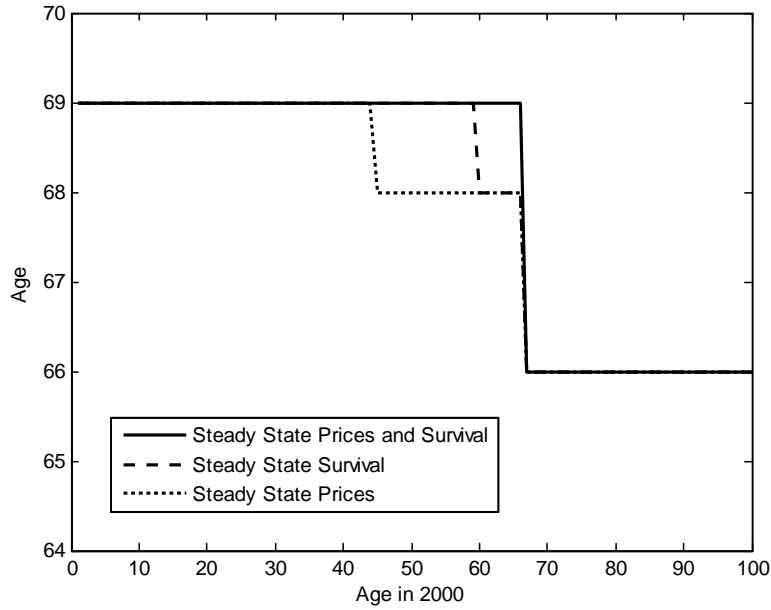


Figure 4.8: Retirement Age of High Skilled Under Different Assumptions about Prices and Survival Probabilities

5.2 Replacement rate reform (RR)

This section considers a reform sustaining fiscal policy by reducing the replacement rate *only*. There are different ways of reducing the replacement rate,²⁸ but a particularly simple form is considered here. In particular, the bend points in $\Omega(\cdot)$ are assumed to remain unchanged, while the slopes of the function are shifted proportionately. In other words, the slopes of $\Omega(\cdot)$ is $\Lambda' = (1 - \varkappa)\Lambda$, where Λ is defined in (4.20) and $\varkappa \in \mathbb{R}^+$ is the factor of proportionality. Thus, \varkappa is the percentage change in the replacement rate.

It is assumed that the reform is implemented at $t = 0$ and that benefits for both workers and current retirees are changed. In a sustainable equilibrium, where no other changes are required, $\varkappa^* = 0.42$. So, given that the current tax policy remains unchanged, i.e. τ equals its initial level of 23.4%, an immediate and universal reduction in the replacement rate of 42% is required. However, even under this policy, the government builds up a substantial net-asset position of 80% of GNP to satisfy the government's long-run budget constraint; see Panel 1 of Figure 4.6. Thus, while expenditures fall immediately after the reform, due to the universal reduction in benefits, the surplus generated by keeping taxes constant is used to accumulate funds.

²⁸ Including indexing benefits to inflation rather than wages.

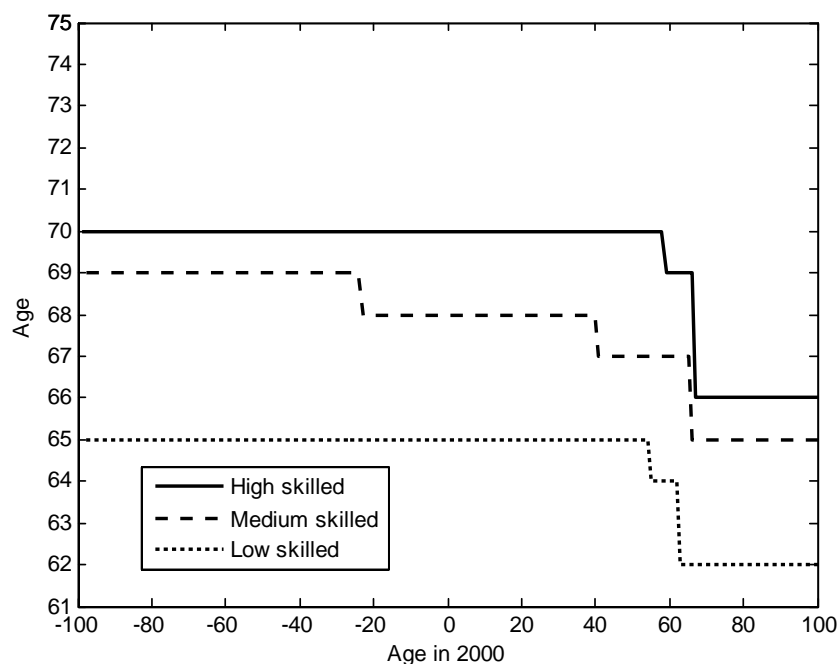


Figure 4.9: Replacement Rate Reform: Retirement Age by Age in Year 2000.

Interest rates mainly drop (see Panel 2) for three reasons: (i) the government runs down debt, (ii) the demographic changes imply more individuals with higher savings, and (iii) savings rise due to the reduction in social security benefits. Notice that the interest rate falls below the interest rate in the Tax Reform economy, even though the government saves less. This mainly occurs because the decline in benefits increases the incentive to save which is reflected in a higher capital per capita ratio (Panel 4).

Although wages rise beyond the wage rate in the Tax Reform economy, efficiency hours per capita are higher under the Replacement Rate Reform. This is primarily driven by the delay in retirement under the reform (see Figure 4.9) which increases efficiency hours. In the final steady state, the low, medium and high skilled retire at the age of 65, 69 and 70, respectively. Thus, the Replacement Rate Reform implies a 3-4 year delay in retirement, which is about one year later than in the Tax Reform economy. Interestingly, the additional years of delay are *not* due to the change in the replacement rate.

Table 4.6 decomposes the change in the retirement age in the same manner as table 4.5. As can be seen from row V of table 4.6, the reduction in the replacement rate has a relatively small impact on the retirement decision. In fact, the reduction

Table 4.6: Replacement Rate Reform - Decomposition of the change in the retirement age

	Low skilled	Medium skilled	High skilled
Initial Period	62	65	66
Δw	62	65	66
$\Delta w + \Delta r$	64	67	69
$\Delta r + \Delta w + \Delta s$	65	68	70
$\Delta r + \Delta w + \Delta s + \Delta \Lambda$	65	69	70

in benefits only induces the medium skilled to postpone retirement.²⁹ The major driving force for the delay in retirement runs via the general equilibrium effect, in particular the reduction in interest rates. This is confirmed by Row III of Table 4.6. The retirement response is larger than in the Tax Reform economy because the interest rate falls below the interest rate in the Tax Reform economy.

It is interesting to compare the retirement responses found here with those found in the microeconomic literature. As mentioned in the Introduction, the microeconomic studies generally find that a 20% reduction in the replacement rate delays retirement by about 0-3 months. In contrast, the experiment here shows that a 43% reduction in the replacement rate results in a 3-4 year delay in retirement. However, consistent with the microeconomic literature, the direct effect of the benefit reduction is minor, and it is dwarfed by the indirect effect via interest rates. Thus, the effect of a reduction in the replacement rate can be substantially larger than suggested by the microeconomic literature.

5.3 Full Retirement Age Reform (FR)

Now, consider reforming the Full Retirement Age, J^F . J^F is the age at which the retiree receives 100% of the insurance amount, currently standing at the age of 65. For each year before J^F the individual starts collecting benefits, she receives a punishment of 6.7% (RER). In contrast, for each year that retirement is delayed beyond J^F , a credit of 6% is given (DRC). Thus, an increase in J^F implies a reduction in benefits for any given retirement age.

It is assumed that a new J^F is implemented at $t = 0$ and that benefits for both workers and current retirees are recomputed in accordance with the new J^F . Benefits can still be claimed at the age of 62.³⁰

²⁹ Once more, it should be stressed that while on the margin, all individuals demand more retirement, this is not manifested for all because of the discrete nature of "age" in the model.

³⁰ The current rules have an upper bound of 30 percent on the punishment. The upper bound

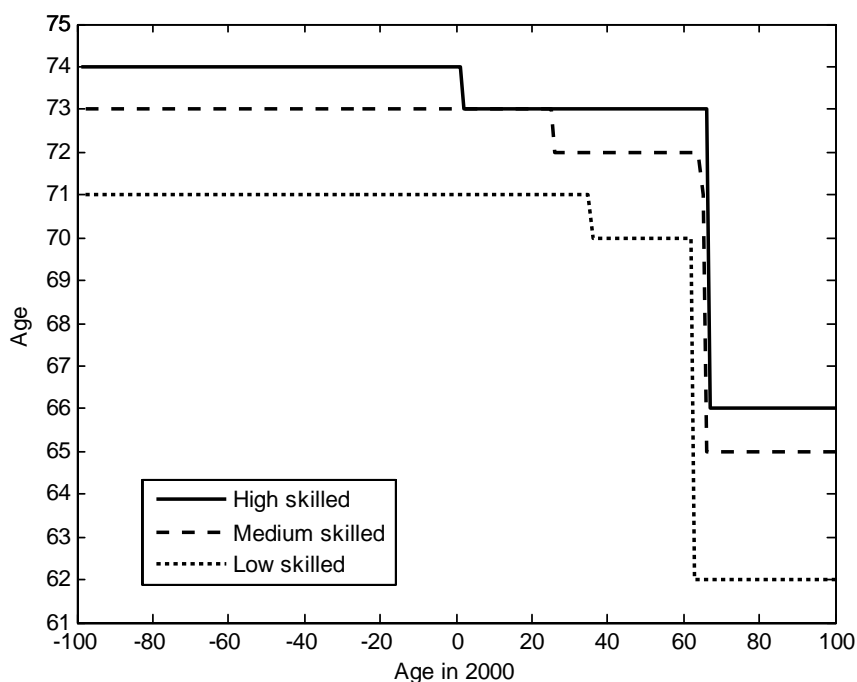


Figure 4.10: Full Retirement Age Reform: Retirement Age by Age in Year 2000.

In a sustainable equilibrium where no other changes are required, $J^{F*} = 73$. That is, an eight year immediate and universal increase in J^F sustains fiscal policy perpetually.³¹ The government builds up a net-asset position of -113% of GNP to finance the demographic changes, see Figure 4.6. The interest rate falls due to (i) the reduction in government debt, (ii) the demographic changes and (iii) the rise in savings caused by the Full Retirement Age Reform, see Panel 2. Interestingly, the dynamics of prices following the reform coincides with the dynamics under the Replacement Rate Reform.

The reform has a significant effect on the retirement decision, see Figure 4.10. Upon introducing the new policy, there is first an abrupt change in the retirement age, followed by a gradual increase. In the final steady state, high and medium skilled delay retirement by eight years to the age of 74 and 73, respectively, while medium skilled delay retirement by nine years to the age of 71. However, low and medium skilled stop working sooner – at the age of 66 and 72 respectively – but

is abandoned in this experiment. Similarly, according to the current rules, DRC is not given past the age of 70. This rule is also abandoned in the current experiment.

³¹ In fact, this reform implies a 0.2 percentage point reduction in τ . The policy that leaves τ unchanged lies between 72 and 73, but the model only allows for integer years.

Table 4.7: Full Retirement Age Reform - Decomposition of the change in the retirement age

	Low skilled	Medium skilled	High skilled
Initial Period	62	65	66
Δw	62	65	66
$\Delta w + \Delta r$	64	67	69
$\Delta r + \Delta w + \Delta s$	65	68	70
$\Delta r + \Delta w + \Delta s + \Delta J^F$	71	73	74

postpone collecting benefits. Although the zero constraint on labor supply is binding from the age of 66 [72] for the low [medium] skilled, there are strong incentives to delay claiming benefits. In particular, collecting benefits from the age of 66 [72] would imply a reduction in benefits of 47% [6.7%] percent relative to retirement at J^{F*} . Instead, the worker chooses to stop working and lives off accumulated savings until it becomes worthwhile to draw benefits. By delaying to claim benefits, the low [medium] skilled only face a reduction in benefits of 13% [0%] relative to claiming benefits at J^{F*} .

Recall that prices and survival probabilities are the same in the Replacement Rate Reform economy and the Full Retirement Age Reform economy. Therefore, the differences in retirement behavior between these two economies must be driven by differences in social security rules. A comparison between Table 4.6 and Table 4.7 confirms this conjecture. Only row V differs between the two economies. Thus, the change in the Full Retirement Age has an enormous impact on retirement behavior. The policy change adds 4-6 years to the retirement age, which also explains why the change in retirement behavior occurs so abruptly.

Figure 4.11 compares the effective dependency ratio, the ratio between the number of beneficiaries and the population in the labor force, for the three experiments. There is a large difference in the effective dependency ratio of the FRA reform and the two other reforms.

Thus, the finding here is that J^F is an important determinant of the retirement age. This echoes findings in the microeconomic literature. In particular, the hazard rate for claiming benefits is particularly large around the Full Retirement Age and the Early Retirement Age (see e.g. Rust and Phelan (1997)).

Under current legislation, J^F is set to increase gradually to eventually reach the age of 67 eventually for cohorts born after 1960. The experiment conducted in this section suggests that this is unlikely to contribute much to sustain fiscal policy in the long run. First, because the legislated change in J^F is way too small to have any

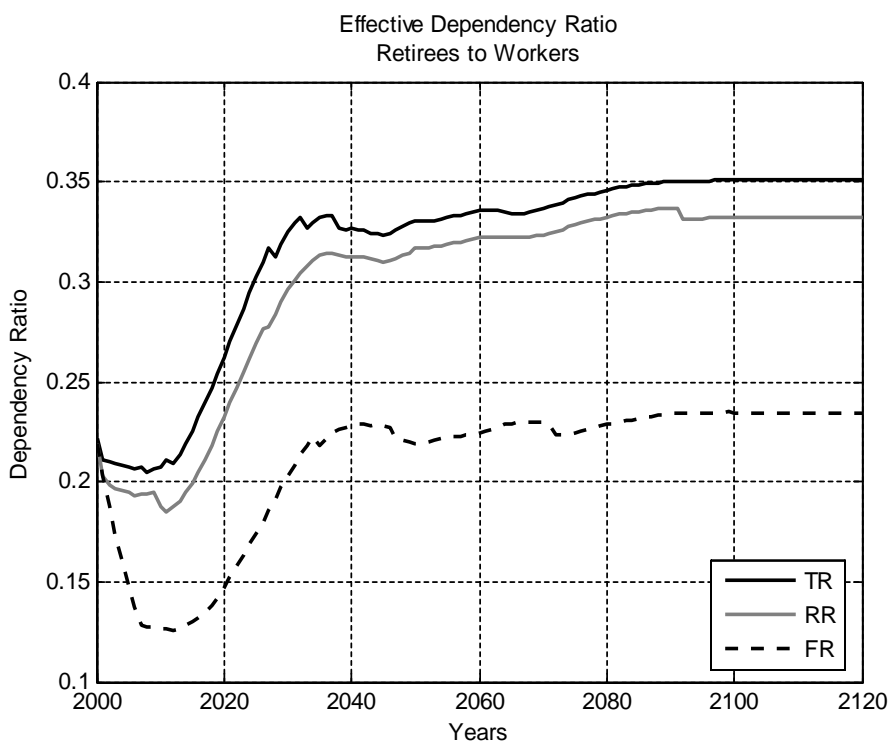


Figure 4.11: Effective Dependency Ratio, 2000-2120.

substantial impact on sustainability. Second, the change, as legislated, will occur gradually (which may be optimal from a welfare perspective). The experiments conducted here assume that the sustainable policy is implemented immediately and universally. If the changes were instead implemented gradually, the required changes would be even larger.

5.4 Are Retirement Responses Important for Sustainability?

Is it delayed retirement *per se* that achieves sustainability or is it the fiscal changes? This section addresses this question by letting the retirement age remain constant at its initial level, and conducting the same experiments as in the previous sub-sections. Table 4.8 reports the resulting policies, as compared to the case where retirement is endogenous.

Although retirement responses are large even in the Tax Reform economy, this only marginally contributes to sustain fiscal policy. In fact, holding constant the retirement age only implies a 0.5 percentage point higher sustainable tax rate. Sim-

Table 4.8: Are Retirement Responses Important?

	Fixed Retirement	Endogenous Retirement
Tax Reform	$\tau^{**} = 29.4\%$	$\tau^* = 28.9\%$
Replacement Rate Reform	$\varkappa^{**} = 0.51$	$\varkappa^* = 0.42$
Full Retirement Age Reform	$J^{F**} = 69$	$J^{F*} = 73$

ilarly, the Replacement Rate Reform economy requires a 51% cut in benefits to sustain fiscal policy when the retirement age is held fixed. Thus, retirement responses contribute positively to sustainability under these two reforms, but only marginally so. The reason is that U.S. social security is roughly actuarially fair. Thus, the present discounted value of benefits is roughly the same, irrespective of the choice of retirement age. That is, most of the effect on public coffers is due to the mechanical effect of changing benefits or taxes (c.f. Coile and Gruber (2003)).

Under the Full Retirement Age Reform, behavioral responses are crucial. In fact, holding the retirement age constant, it would be sufficient to change J^F to age 69 to sustain fiscal policy. Since individuals in this experiment are unable to respond to the change in J^F they are forced to accept large cuts in benefits, due to the punishment for early retirement. This also explains why such a large change in J^F is required to sustain fiscal policy: Individuals respond by delaying retirement, thereby offsetting the reduction in benefits implied by the increase in J^F .

5.5 Sensitivity

This section studies the sensitivity of the model. In a first experiment, the model is re-calibrated to a net-interest rate of 6%, which significantly reduces the required fiscal responses of the government; see Table 4.9. For instance, the tax hike required to sustain fiscal policy is only 2.5 percentage points. The reason is that the return on the government's assets is larger, which implies that a smaller net-asset position is required to sustain fiscal policy. The retirement responses are still substantial, since the interest rate also drops in this economy. It is interesting to note that the J^F required to sustain fiscal policy is only 69 in this economy.

In a second experiment, the model is re-calibrated to only having one skill-group.

Table 4.9: Sensitivity

	Benchmark	6% Net-Interest Rate	One Skill-Group
Tax Reform, $\Delta\tau$ (% points)	5.5	2.4	4.8
Replacement Rate Reform, \varkappa	0.42	0.24	0.32
Full Retirement Age Reform, J^F	73	69	71

This skill-group has the average productivity profile of the benchmark economy. In this economy, fiscal adjustments are smaller than in the benchmark case. The primary reason is that the high- and medium-skilled constitute a larger fraction of retirees in the future. These groups receive higher social security benefits. Not accounting for this compositional effect results in an under-estimate of the social security liabilities.

Future work should also explore the sensitivity with respect to the productivity profiles at old age and the Frisch elasticity.

6 Concluding Remarks

This paper makes four contributions to the current debate on the sustainability of fiscal policy. First, it develops a framework where fiscal sustainability and the retirement decision are jointly determined. Second, the paper shows that the effect of social security reform on retirement behavior can be much larger than what is suggested by the microeconomic literature. A reduction in the replacement rate, for example, increases saving and reduces interest rates. A lower interest rate, in turn, induces a delay in retirement. This indirect effect of reform is substantially larger than the direct effect of reducing the replacement rate. The paper also shows that changes in the Full Retirement Age can have a large impact on retirement behavior. In this case, the induced change in retirement behavior is both due to the direct effect and the indirect general equilibrium effect. Third, the paper constructs three policies that sustain fiscal policy in the face of the aging population: (i) immediately raising the general tax rate by 5.5 percentage points, (ii) immediately and universally reducing the replacement rate by 42% (at unchanged taxes) or (iii) immediately and universally raising the Full Retirement Age to 73 (at unchanged taxes). The paper finds that the set of sustainable fiscal policies considered here reduces the interest rates by 150-200 basis points over the long term and delays retirement by 3-9 years, depending on the reform. However, a delay in retirement is not in itself sufficient to sustain fiscal policy. The reason is that the U.S. social security system is roughly actuarially fair, which implies that even with large changes in retirement behavior, the U.S. government will have to make major fiscal adjustments to sustain fiscal policy.

A number of caveats are in place here. First, the model assumes individuals to have no bequest motive. Several papers argue that this is important for achieving realistic wealth distributions (see e.g. De Nardi (2004) and Cagetti and De Nardi

(2005)). Future work should allow for a bequest motive. In particular, all savings in the model are due to life-cycle savings. Therefore, changes in the social security system will have a large effect on interest rates. Introducing a bequest motive is likely to reduce the effect on the interest rate of reforming social security, and will therefore also mitigate the effect on retirement behavior. However, since the effect in this model partly stems from government savings, the main conclusion is likely to remain unchanged.³² Second, annuity markets are small in practice (Eichenbaum and Peled (1987)). Future work should therefore consider an environment without annuity markets. Third, the model assumes that the U.S. government takes immediate action to sustain fiscal policy. Delaying the reform will imply that larger changes in fiscal policy are required, for two reasons: (i) the U.S. government operates in a window of opportunity. The demographic changes will manifest themselves 2010-2030 and reforms implemented prior to that are likely to considerably ease the transition. (ii) If no action is taken now, debt is likely to increase in the short term making the required fiscal adjustments even larger. Future work should consider reforms implemented at later dates.

³² In the tax reform economy, for instance, the reduction in interest rates mainly stems from the increase in government savings.

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7 The Algorithm

7.1 The Status Quo Economy

The transition path of a model can be substantially affected by the choice of initial conditions. Therefore, it is crucial to calibrate initial conditions in a way such that they do not affect the subsequent policy experiments in a substantive way.³³ This problem is especially difficult to handle in models trying to replicate the demographic developments over the present century. This section explains how the initial conditions are generated for this paper.

To calibrate the government sector of the economy and get the initial conditions for asset holdings and past earnings across cohorts and skill groups, a *Status Quo Economy* is used. The Status Quo Economy is characterized by having the population distribution of the U.S. in the year 2000, μ_{2000} , and the cross-sectional survival rates of the year 2000, $\{s_i^{2000}\}_{i=0}^{100}$. Clearly, these two are not jointly consistent with a stationary population distribution. In particular, define the stationary population distribution associated with $\{s_i^{2000}\}_{i=0}^{100}$ and the population growth rate n by $\mu_S(n)$. Then, $\mu_{2000} \neq \mu_S(n)$ for any n . In other words, it is not possible to start the economy in a steady-state, which both has the population distribution and the survival rates of the year 2000. To overcome this problem, the following procedure is used. First, compute the steady-state of the economy given $\{s_i^{2000}\}_{i=0}^{100}$ and a population growth rate n . This gives prices $r(n), w(n)$ and the tax rate $\tau(n)$. It also gives the asset holdings and labor supply decisions across cohorts and skill groups associated with the stationary population distribution, $\mu_S(n)$. Now, assume that each cohort and skill group in μ_{2000} make the same decisions as their counterparts in $\mu_S(n)$. This would be the case if prices and taxes were identical in the two economies,³⁴ i.e. if $r(n) \approx r_{2000}, w(n) \approx w_{2000}$ and $\tau(n) \approx \tau_{2000}$, where $(r_{2000}, w_{2000}, \tau_{2000})$ denotes the prices and tax rate associated with μ_{2000} . Aggregating allocations over cohorts and skill groups given μ_{2000} we can compute r_{2000}, w_{2000} and τ_{2000} . The *Status Quo Economy* is computed by setting n to ensure $r(n) \approx r_{2000}, w(n) \approx w_{2000}$ and $\tau(n) \approx \tau_{2000}$. Moreover, the allocations of each cohort and skill group in μ_{2000} are assumed to be identical to their counterparts in the stationary economy.

³³ Just consider a simple growth model where capital starts above its steady-state versus a case where it starts at its steady-state. It is usually preferred to evaluate policy changes as deviations from a steady state, so as to not confound the effect of initial conditions with the effect of policy.

³⁴ In addition, the history and future of prices and taxes should be the same in the two economies. An implicit assumption when using this procedure is therefore that any past or future deviations in prices and taxes have a negligible impact on current decisions.

To study the stability of this procedure, the survival rates in the Status Quo Economy were assumed to be $\{s_i^{2000}\}_{i=0}^{100}$ for the transition and the debt-to-output ratio indefinitely remains constant at 47.4% of GNP. Indeed, prices and taxes change very little from $t = 0$ to $t = 1$ (less than 0.2%). This suggests that the initial conditions used here do indeed not affect the policy experiments in any substantive way.

7.2 The Equilibrium

This section describes the computation of the equilibrium in the Tax Reform economy, where τ is increased once and for all at $t = 0$ and the sequence of debt $\mathbf{B} = \{B_{t+1}/Y_t\}_{t=0}^{\infty}$ evolves endogenously. All other policy variables either remain fixed throughout the transition or move deterministically. The economy is assumed to reach its steady state at time T .

1. Guess on a vector of retirement ages for each cohort and skill groups, \mathbf{R} .
2. Guess on a vector of debt-to-output ratios, \mathbf{B} .
3. Compute the final steady-state given B_{T+1}/Y_T . This gives $w_t = w_T$, $r_t = r_T$ and $\tau_t = \tau_T$, $\forall t \geq T$.
4. Guess on a sequence of prices $\{w_t\}_{t=0}^{T-1}$ and $\{r_t\}_{t=0}^{T-1}$.
5. For each cohort and skill group, solve for the individual's allocation $\{a_i, h_i\}_{i=0}^I$ given $\mathbf{w} = \{w_t\}_{t=0}^{\infty}$, $\mathbf{r} = \{r_t\}_{t=0}^{\infty}$ and \mathbf{R} .
6. Aggregate assets and labor supply across age- and skill-groups and compute \mathbf{w}' , \mathbf{r}' and $\boldsymbol{\tau}'$. If $\mathbf{w}' \approx \mathbf{w}$ and $\mathbf{r}' \approx \mathbf{r}$ then continue. Otherwise return to 4.
7. If $\tau_t \approx \tau_T \forall t \geq 0$ then continue. Otherwise return to 2.
8. Solve for the optimal retirement age given \mathbf{w} , \mathbf{r} and $\boldsymbol{\tau}$: Define $V(R) \equiv \sum_{i=0}^I \beta^i u(c^*(R), 1 - h^*(R))$, where $c^*(R)$ and $h^*(R)$ denotes the optimal policy rules for consumption and hours worked, respectively, given retirement age R . The optimal retirement age for each cohort and skill group is computed as $R^* = \arg \max \{V(R) | R \in \mathcal{R}\}$ where $\mathcal{R} = \{58, 59, \dots, 100\}$. If $\mathbf{R}' = \mathbf{R}$ then stop. Otherwise return to 1.

When computing the equilibria for the Replacement Rate Reform and the Full Retirement Age reform, a similar procedure is used. However, an additional outer loop is required where the equilibrium Replacement Rate/Full Retirement Age is determined. Moreover, in 7. an extra requirement is that $\tau_T \approx \tau_{2000}$.

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