Budget Forecasting Methods

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Abstract

This document serves as a working paper on techniques used and assumptions made for the purposes of forecasting federal and joint state and local budgets in a stochastic environment over a 75 year horizon. It is a reference for "Uncertain Demographic Futures and Government Budgets in the US," by Ronald Lee, UCB Departments of Economics and Demography; Shripad Tuljapurkar, Department of Biological Sciences, Stanford University; and Ryan Edwards. Last substantive update: August 1998.

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1 Project manifest

This document describes the methods and techniques used to create stochastic budget projections at the federal and aggregated state and local level for

the United States. Our objective is to describe the effects of demographic change on long-run fiscal balance using a stochastic approach rather than the simple "low, medium, high" method of forecasting.

2   Basic theoretical assumptions

Our budget projections are calculated in real terms over the period 1994–2070; we implicitly assume that expected and realized inflation are constant and equal. Population, productivity, and the real interest rate are modeled as independent stochastic processes. Statistical inference based on an empirical distribution (750 "sample runs" through the entire time period covered in the projections) will be used to simplify the analysis. In terms of the budget projections themselves, we attempt to follow many of the procedures used by the Congressional Budgeting Office.

2.1   GDP and the implicit capital stock

We assume that the growth rate of real Gross Domestic Product can be inferred solely through demographic changes in the labor force and the growth in real labor productivity. The national economy is assumed to remain in a "steady state" where the ratio of capital to effective labor stays constant. In our model, the implicit income distribution and labor force participation rates are both fixed through age and sex. That is, the age profile of labor earnings is assumed to remain fixed through time, and total labor earnings increase along with the working-age population and their productivity. Comparatively, the CBO forecasts GDP based on a Cobb-Douglas production function that uses separate estimates of total factor productivity, the labor force, *and* the capital stock.

It is a generally accepted fact that the shares of income earned by labor and capital in the US have remained roughly constant over time, somewhere around a ratio of 2 to 1 ($\alpha_k \approx 1/3$). If we assume production is Cobb-Douglas and exhibits constant returns to scale, in the steady state under competitive pricing, labor and capital earn fixed shares of GDP through time.[1]

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[1]If capital and labor earn their marginal products and CRS holds, it can be shown that the wage bill plus the total return to capital equals output:

$$wL + rK \quad = \quad \frac{\partial F}{\partial L}L + \frac{\partial F}{\partial K}K$$

We therefore assume that the total wage bill will maintain its constant share of GDP through time, which allows us to recover GDP from total labor earnings each year.[2] It should be noted that the path of *wages*, narrowly defined, may depart from the path of *total compensation* through time without any adverse effects on our methods of projection.[3]

A simple example is illustrious of our methods. Suppose all workers are homogeneous, and let there be 100 workers in period 0, who earn 100 units in wages and 10 units in benefits, so total compensation is 110. Let GDP be 200 that year, so our method of projection assigns a fixed multiplier of 2 to wage earnings. Suppose the supply of labor grows to 200 workers by period 1, and suppose workers are twice as productive as they were before. Under the assumption of a constant K/AL, K must increase by a factor of $2 \times 2 = 4$, and so any CRS production function would indicate that output quadruples to 800. Total compensation also quadruples to 440 units, since labor's share of output remains fixed.

Our method of calculating output would merely take the multiplier of 2 from period 0 and the productivity multiplier, which is also 2, and it would recover GDP by scaling up the contribution of 200 period-1 workers to $200 \times 2 \times 2 = 800$, which is the same number recovered above.[4]

$$
\begin{aligned}
&= AL(f(k) - kf'(k)) + ALkf'(k) \\
&= ALf(k) = F(K, AL),
\end{aligned}
\tag{1}
$$

where $F(\cdot)$ exhibits constant returns to scale, A represents labor efficiency, $k \equiv K/AL$, and $f(k) \equiv F(k, 1)$. Furthermore, if the economy is in a steady state ($\dot{k} = 0$), then the wage bill as a proportion of GDP is fixed through time, since wL and F are growing at the same rate.

Notice that the steady-state growth rate of output is exactly the growth rate of the labor force plus the productivity growth rate.

[2]Total labor earnings are derived through the use of an age profile based on CPS data; see section 3. Since the age profile times the population vector generates only a fraction of the two-thirds of national income we expect labor to earn, we apply a fixed scaling factor to every year's labor income on top of the productivity growth.

[3]This is an important point because it is likely to be the case that the wage share of total compensation will be in decline. We believe that as medical benefits and other forms of social insurance at the state and local level continue to increase, employers will pass on new costs to workers in the form of wage reductions, even though labor continues to be compensated at its full marginal product. This assumption coincides with the prevailing literature on the incidence of UI costs; see Gruber and Krueger (1991).

[4]A crucial point is that the wage share of total compensation in period 1 may be different than in period 0, but as long as we have a valid starting point and the assumptions of CRS and competitive factor prices it doesn't matter.

The crucial Solow balanced-growth condition is that capital per labor efficiency unit is constant. Given that our population is becoming older — an implicit change in the population growth rate which should force an increasing capital/labor ratio — it isn't immediately apparent that K/AL really will remain fixed through time.[5] For the following reasons, we feel it is a reasonable assumption to keep K/AL fixed: We are unconcerned with modeling cyclical variations in the economy; and we do not explicitly track the growth in the capital stock through individual savings choices. One line of research that may bear implications for the $\dot{k} = 0$ assumption concerns the potential for changes in age-specific labor demand by firms.

Capital's share of output is therefore a residual in our model, the difference of GDP and labor earnings. Since the share of output paid to capital is necessarily constant over time, budget programs that are implicitly tied to capital earnings must grow with output. Other studies (Auerbach, Kotlikoff and Gokhale, 1991) have employed a more sophisticated scheme of projecting taxes on capital based on age profiles. Here, we neglect a more formal modeling of the capital stock, which would require another layer of questionable assumptions concerning saving behavior, in order to concentrate on the demographic forces at work in future fiscal policy. Futute research efforts might wed our stochastic methods with a more rigorous treatment of capital.

In our model, federal collections of corporate taxes cannot increase faster than output for long, or else the average tax rate on total capital earnings in the economy would be implicitly rising to unreasonable levels. Since we do not account endogenously for the behavioral effects of taxation, it is therefore important to confine average tax rates to plausible values.

2.2 Demographics

The population projections we use are imported from Lee and Tuljapurkar's dataset, which exhibits asymptotic fertility averaging 1.9 and mortality following the Lee-Carter rate of decline. The initial population totals are taken from the Social Security Administration, and the long-term immigration assumptions are the intermediate estimates of Social Security. Male and female populations are estimated separately in five-year age cohort bins (e.g., ages 0–4, 5–9, etc.) for every fifth year of the time period. Race and ethnicity are

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[5]For a different view of the implications of Solow/Ramsey-style growth models under changing US demographics, see Cutler, Poterba, Sheiner and Summers (1990).

ignored. Cubic splines are used to interpolate for single-year age bins.[6]

With forecasts of population totals, productivity growth rates, real interest rates, and GDP, we proceed to recover fiscal totals per year in each of the 750 runs. Federal balances and state and local balances are calculated separately. Fiscal amounts assigned to cohorts are estimated separately by gender. This method is problematic when the age-specific data used to create a profile vector is aggregated to the household or family unit rather than to the individual. We do not attempt to model households in our projections; rather, we assume that children generally do not pay taxes unless they are categorized as heads of household, and that married couples' joint household taxes and income are split equally in a flat average between the male and female. Single heads of household accrue the entire household assignment themselves.

2.3   Budget rules

In nearly every industrialized nation, sustaining current fiscal policies while populations age is projected to become increasingly difficult. With shrinking tax bases relative to the obligations of the modern welfare state, countries will eventually be forced to alter course or else face debt crises that would trigger change regardless. In the United States, the future paths of federal expenditures, focused almost singularly on the growing ranks of elderly Americans, threatens to explode the level of debt relative to GDP from a factor of about 0.6 today to more than 6 by 2070.[7] It is highly unlikely that interest rates, inflation, and probably even productivity would remain stable under such a scenario.

As remarked by numerous other scholars, unsustainable policies simply will not be sustained. The difficulty of providing a reasonable set of budget projections still remains, however. Knowing that one course of history will

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[6]The CBO (1997: 48) believes that interpolation by cubic splines "generates implausibly wide swings in growth rates" in the early portion of the projection. While cubic splines necessarily create data that may in fact not exist, we feel it is a better method than a more standard exponential or "linear-logarithmic" technique. The latter tends to create upward bias in between-year growth rates of any linear combination of the age bins; the growth rate of the sum converges to the growth rate of the fastest growing group. While such an effect should in theory take a long time to manifest itself, we encountered the upward bias even within the window of the four-year interpolations.

[7]The factor of six is the average debt-to-GDP ratio that we forecast for 2070, *even with* long-term stability of the OASDI Trust Fund at a rate of 2.5 times next year's liabilities.

not obtain offers relatively little substantive information about what courses are *likely* to obtain. A choice must be made, therefore, as to how one should best model fiscal policies through time subject to some kind of intertemporal budget constraint.

An intertemporal budget constraint implicitly requires the debt to GDP ratio to have a finite limit over an infinite horizon. We could either make our projections infinite and impose a true intertemporal budget constraint, or we can choose to impose some other kind of balancing mechanism over a finite horizon, namely the seventy-five years of the projection. The second option is currently implemented in this paper, although we also consider a pure "laissez-faire" world in which taxes and expenditures move without regard to levels of debt.

While our upper bound is somewhat arbitrary, it seems logical that some limit on the debt-to-GDP ratio should be imposed. Currently we use 80% percent. Figure 1 shows the historical path of the ratio over the past forty years, using data obtained from the St. Louis Federal Reserve's FRED database. Based on that, the debt-to-GDP ratio seems to follow an increasing trend. On the other hand, figure 2, depicting data from the 1999 Budget that covers a longer historical period, displays a more random-noise relationship around 0.8.

The debt concept we employ at the federal level is the total debt outstanding minus debt held by the Social Security Trust Fund. This simplification abstracts from the numerous other trust funds contained within the unified federal budget, but we believe it is justified given the unique and important nature of the OASDI system. Social Security's internal balance is subject to its own set of rules. The traditional concept of current flows (primary deficits) must be altered somewhat under these assumptions. The unified federal budget counts the contributions of the OASDI system within current operations, but we do not. See appendix J for details.

We currently constrain the Social Security Trust Fund to be held steady at 2.5 times the next year's OASDI obligations in the long run. Previous tax hikes have placed the Trust Fund ratio on an increasing trajectory; the internal rule we employ maintains a value of 2.5 even when retiring Baby Boomers and longer-living cohorts begin to strain the system. Payroll taxes are hiked up to maintain that balance as needed.[8]

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[8]As of this writing, June 27, 2003, the balancing algorithm for the OASDI system remains in its original, somewhat unrealistic form: payroll taxes are adjusted in each year
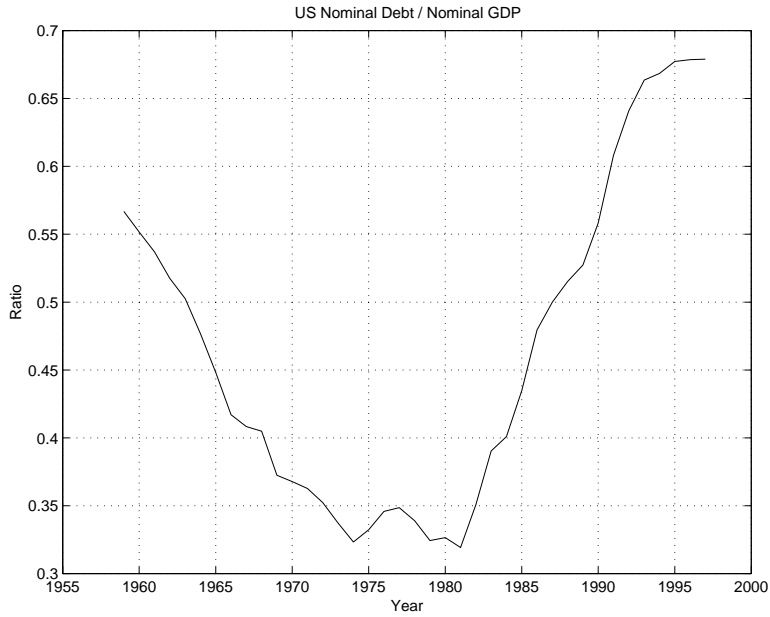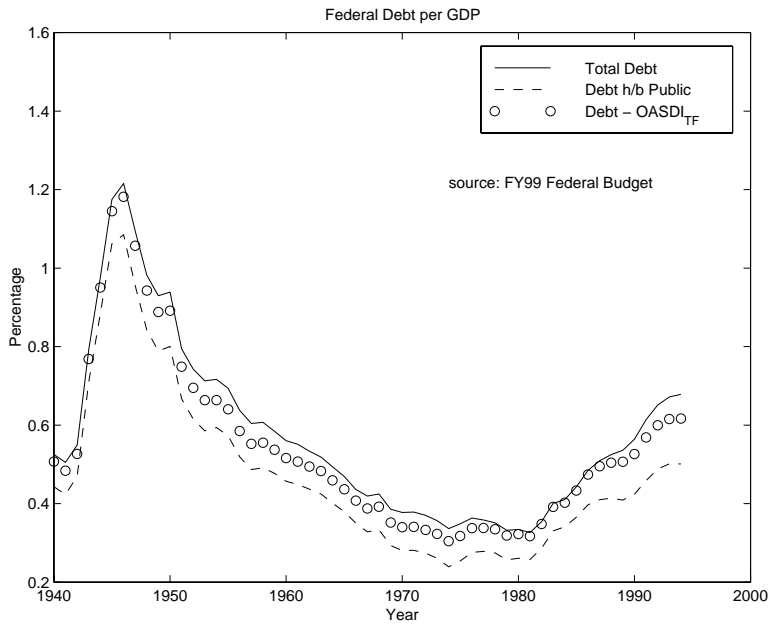
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Figure 1: The Historical Debt to GDP Ratio

US Nominal Debt / Nominal GDP

Figure 2: The Historical Debt to GDP Ratio

Federal Debt per GDP

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At the rest of the federal level, taxes are adjusted so that the net federal debt (total debt outstanding minus the OASDI Trust Fund balance) is fixed at 0.8 of GDP, given the Trust Fund balance. We tried many different balancing algorithms and found that the primary difficulty was establishing smoothness both in tax rates and the debt to GDP ratio. As mentioned previously, our simplifying assumptions concerning the capital stock require that tax rates and variations in tax rates be kept within reasonable bounds.

Smoothness is a characteristic that seems difficult to reconcile in a world based on current fiscal policy and perfect information. If smoothness is desired, one might argue, why wouldn't the government adjust current policy based on expectations about future liabilities so as to keep tax rates constant and minimize distortions? In the limit, a distortion-minimizing budget authority would do so. Between that extreme and its polar opposite, projections in which government leave fiscal policy completely untouched as deficits and debts swell to ridiculous proportions, we believe a reasonable assumption is that governments balance over finite horizons, as suggested above.

Perfect foresight over any horizon is a highly questionable assumption, but it proves necessary here, as a rational expectations model would be exceedingly difficult to implement in this chiefly autoregressive, four-variable stochastic framework.[9] Perfect information over a limited horizon seems like a reasonable compromise, however, while we grant that research has shown the government seemingly incapable of projecting budgets even over the short run without a rosy bias (see Auerbach, 1994).

Appendix K.1 contains the exact formulation of our balancing algorithm. During each year in every stochastic run, the federal government looks five years into the future. If $D_{t+5}/Y_{t+5} > 0.8$, or if taxes have already been adjusted in a previous year of the projection, then all non-OASDI taxes are adjusted for next year and every subsequent year by a constant percentage over what they would otherwise have been, so that in five years the debt to GDP target is reached exactly. Since this algorithm operates *every* year,

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so that the Trust Fund ratio is kept exactly at 2.5 once it has fallen, about ten to fifteen years in the future. Eventually a more refined algorithm that imposes balance in a more continuous fashion will be employed.

[9]While the expected value of any variable in any year given information *in the first year* could readily be obtained from the empirical distribution, once the projection moves beyond the first year, no longer is such a calculation possible because the information set changes. We'd have to project n different stochastic runs *recursively* for every single year in order to use such a scheme.

taxes change virtually every year by some (usually small) amount, and debt to GDP stays within a confidence interval of 0.8 while never reaching it exactly, per se. This balancing scheme yields tax hikes that are of reasonable size; the worst five percent of cases in any year require incremental hikes of eight percent.[10]

As a counterpoint, one might consider the method of generational accounting, pioneered by Auerbach, Kotlikoff and Gokhale (1991). Generational accounting employs a truly intertemporal budget constraint, in which the debt-to-GDP limit is not subject to a strict upper bound, but the present values of indebtedness and obligations must not exceed the present value of revenues. Choosing one adjustment path out of a plethora or possibilities remains a daunting problem here, however. In fact, a major criticism of generational accounting is that the particular path it chooses — in which current living generations and all unborn generations face substantially different lifetime tax schedules even while they may be living contemporaneously — is far from realistic. Our projections may be arbitrary to a certain degree in their choice of adjustment path, but that is hardly a unique criticism of our model.

At the state and local level, we follow the same kind of fiscal rule as in the federal calculations: a debt to GDP ratio is fixed and maintained throughout time. In data collected by the Census Bureau[11] a *net* debt to GDP ratio seemed to hold roughly constant over the three years of data that were readily available: 1992, 1993, and 1994. We define net debt to be total debt minus general fund assets (excluding trust fund assets).

Since state and local governments follow vastly different accounting conventions and finance procedures than does their federal counterpart, it proves challenging to extend our analysis from the federal level downward in terms of a budget concept. Generally speaking, it is most natural to separate state and local budgets into two broad categories: the general fund (current taxes and expenditures) and trusts. Section 6 details the list of programs that we project.

Most states follow some kind of budget-balancing regime insofar as current expenditures are concerned. Bohn and Inman (1996) describe how states

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[10]It is important to note that the worst cases don't remain the worst through time due to the underlying autoregressive structure of the variables. In contrast, were the CBO projections to include tax hikes, their "high-cost" projection would always require the most adjustment in any given year.

[11]State and Local Government Finance Estimates, at www.census.gov/govs/www/

Table 1: S–L Debt and GDP, $bn

Year	Assets	Debt	Net Debt	ND/GDP
1992	772.5	949.1	176.6	2.77%
1993	803.1	991.6	188.5	2.81%
1994	845.4	1048.0	202.6	2.86%

adhere to various forms of balanced-budget statutes and provisions by cutting expenditures when necessary and running surpluses when possible, saving up funds in "rainy day" accounts that are used when times worsen. While it may appear at first glance that since many states are legally required to keep their budgets balanced it would behoove us to project zero deficits, it seems more realistic to impose a net debt to GDP limit on the states instead, since they build up and draw down funds in order to smooth the path of spending.

The levels of general fund assets, debt, net debt, and net debt to US GDP are shown in table 1. Trust fund assets are excluded, since at the state and local level these trusts are virtually fully funded and separate from current government accounts. While the interest rates paid on debt and that earned on assets are not exactly equal, the discrepancy is small. Net indebtedness is thus measured by the excess of debt over assets.

Our list of current expenditures is heavily weighted toward younger Americans (see section 6.1), while the corresponding tax base is not. The result is that taxes grow much more quickly than outlays at the state and local level, since we have taken more volatile (yet in reality, fully funded!) elements (e.g., retirement) off the table.

As a result, we reformulate the regime that maintains the debt to GDP ratio in the state and local case. We take the first year's fiscal totals and net debt level, and we lower taxes in the first and every subsequent year in order to keep net debt as a share of GDP fixed through time.[12]

Expenditures are left completely alone; since there are no pressures to run deficits in the general fund as we describe it, no spending increases are forced. Instead, the surplus is returned to the public in the form of lower taxes. As with everything else in our model, we model these tax "cuts" with

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[12]As of this writing, June 27, 2003, the balancing algorithm for the state and local sector remains in its original form: taxes are adjusted in each year so that net debt to GDP is fixed exactly. An algorithm like used for the federal budget could easily be adapted for the state and local budgets and will likely be developed shortly.

absolutely no general equilibrium effects on labor supply or output.

In the aggregate, tax hikes at the federal level are partially offset by tax cuts at the state and local level. A general rise in average tax rates over time still results, however. While there are problems with assuming that tax hikes are entirely lump-sum and non-distortionary, we believe that such a simplification is a fair one. As long as the federal government is expected to provide the services of a welfare state, it is reasonable to assume that taxpayers will fund it up to a given debt-to-GDP level, shifting resources away from state and local governments as populations age.

3 Forecast methods: variables

Fertility and mortality rates are stochastic in the Lee-Carter model. In addition, we allow the real rate of productivity growth in the economy as well as the real rate of interest to be independent stochastic processes.

3.1 Productivity

We model the productivity growth rate ρ (that is, the log difference of the level of labor productivity) as an ARIMA(1,1,0) process that converges toward a long-run mean:

$$\rho_t - \mu_\rho = \beta_\rho(\rho_{t-1} - \mu_\rho) + \epsilon_{\rho,t}, \tag{2}$$

where μ_ρ is the long-run mean.

We fit (2) to data on output per worker hour in the nonfarm business sector from 1947 through 1998, purged of age composition effects. See Lee and Tuljapurkar (1998) for more background.

THIS SECTION NEEDS MAJOR UPDATING. The long-run mean of labor productivity is assumed to be 1.8%, following the sweeping revision of the National Income and Product Accounts back to 1959 this past October.

The long-run mean of labor productivity growth is assumed to be 1.3 percent, roughly in line with the current consensus among government agencies (CBO, CEA, OMB). While productivity growth exhibited a sharp break in trend around 1973, we nevertheless decided to estimate (2) with a single μ_ρ for the entire time period. This technique may overstate the variance of ρ if

the long-run trend were truly to remain fixed over time. We suspect, however, that the long-run mean is itself subject to variation. If so, our method assigns to ρ that additional variability.

Assuming $\mu_\rho = 0.0130$, we find the standard deviation of $\epsilon_{\rho,t}$ to be 0.0191, and β_ρ is fit at 0.4178. Demographically-corrected labor force productivity grew at 2.39% between 1997 and 1998.

Growth in covered wages. The productivity growth rate ρ is equivalent to the growth rate of labor productivity. For determining the rate of growth in average wages in OASDI covered employment, ρ^c — the key productivity growth rate for projecting Social Security finances — we *subtract* 0.3 percentage points from each year's labor productivity growth rate; $\rho_t^c = \rho_t - 0.003$.

For their middle, or "alternative II" scenario, The OASDI Trustees project the gap between covered wage growth and labor productivity growth at 0.4 percentage points[13], consisting of a one tenth decline in average hours worked per year, two tenths decline due to the growth in non-wage compensation relative to wage compensation, and one tenth due to the wedge between CPI inflation and GDP inflation.[14]

We choose to omit consideration of inflation, so our gap rate is 0.3 percentage points. While that differential is small, it does imply roughly a 20 percent drop in the wage share of total compensation after the 75 years of our projection window.

Forecasting GDP The labor productivity growth rate ρ is combined with population estimates to create a GDP series based on an age schedule of wage earnings drawn from the Current Population Survey.[15] This age schedule is assumed to remain constant through the entire time period. That is to say, the age-specific labor force participation rates are assumed to remain constant across sexes through time. While this may not seem entirely representative of recent trends in labor force characteristics, we believe it is a fair assumption given the large amount of uncertainty inherent in long-term

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[13]See the 1999 OASDI Trustees Report, p. 148, bottom.

[14]That is, CPI inflation proceeds at a 0.1 percent faster clip than GDP inflation. So although workers, paid a share of GDP, see their nominal wages rise with nominal GDP, the real buying power of that compensation is rising less quickly than real GDP. The relative price of their consumption basket is edging higher.

[15]The CPS variable used to proxy wage income is "Earned Income," which we split between spouses within households when applicable.

Figure 3: GDP Growth Rates Through Time
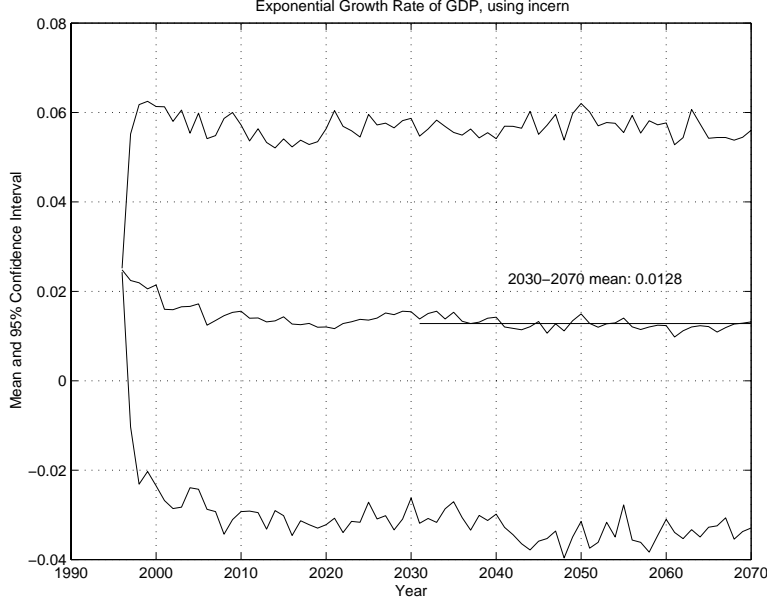
projections. A rescale factor that transforms total wage earnings into GDP is derived from the initial year's recorded GDP divided by the initial year's total earnings. This rescale factor should roughly be labor's (constant) share of GDP.

$$GDP_i = \sum_j \left(p_{i,j} \alpha_j R \Pi_{t=0}^{t=i}(1 + g_t) \right) \tag{3}$$

Thus GDP in year i is the sum over all age cohorts j in that year of the cohort population $p_{i,j}$ times the corresponding age schedule factor α_j times the cumulative product of productivity growth inflation factors $(1 + g_t)$ from the initial year to the current year times the rescale factor R. Since R and $\Pi_{t=0}^{t=i}(1 + g_t)$ are constant in j, the GDP series can be rewritten:

$$GDP_i = R \left(\Pi_{t=0}^{t=i}(1 + g_t) \right) \sum_j p_{i,j} \alpha_j \tag{4}$$

The GDP series that results shows a long-term growth rate of roughly 1.38%. Figure 3 depicts the average growth rate in real GDP flanked by upper and lower 95% confidence intervals.

As mentioned in section 1, the CBO uses a different method of projecting GDP based on a production function that requires estimates of the labor

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force, the capital stock, and the year-by-year growth in total factor productivity. These calculations have been changed by CBO over the past year. The following paragraphs from the first chapter of *Long-Term Budgetary Pressures and Policy Options (March 1997)* discuss the changes:

"CBO made two major technical changes in its long-term budget model since it was unveiled last May. First, CBO altered its method for aggregating the components of investment into a measure of the capital stock. The new procedure is now consistent with CBO's method of preparing its medium-term (10-year) projections. (That revision also changed the definition of total factor productivity in the model.) Second, partly as a result of changing its measure of the capital stock, CBO also increased its estimate of the long-term growth of total factor productivity. Last May, CBO assumed that TFP would grow about 0.7 percent a year; it is now assumed to grow at 1 percent a year. The new rate is consistent with the historical rate of growth of CBO's revised measure of TFP from 1952 to 1996, but it is noticeably faster than what CBO assumes in its medium-term projections from 1997 to 2007.

"The revision in the growth of TFP after 2007 significantly raises CBO's estimates of the growth rate of potential GDP in the long run. Last May, CBO projected that, without economic feedbacks, the trend in the annual growth rate of real GDP will slip from about 2.0 percent in 2005 to 1.3 percent in 2020, reflecting the slowing growth of the labor force. CBO now expects it to decline to 1.7 percent. Thus, although the labor force is still expected to grow much more slowly when the baby boomers retire, the pickup in TFP growth after 2007 offsets some of that decline. CBO's assumption about growth in real GDP in the long run is more optimistic than the Social Security Administration's. Implicitly, CBO incorporates the chance of a period of exceptionally high growth in productivity. Of course, making such long-term projections involves huge uncertainties, and analysts disagree about the appropriate assumption for growth in productivity."

Since we rely on the interaction of stochastic processes to determine GDP, CBO's change of heart concerning long-run total factor productivity does not directly affect our projection methods. It may be relevant down the road in refining our assumptions, however.

As a point of reference, in the Immigration paper we used a GDP series derived from CBO estimates (and the implicit year-over-year growth rate of GDP) to project fiscal programs. Implicitly assuming a constant labor force participation profile over the years of the projection, we inflated the real GDP series from the CBO by a factor equal to the year-by-year ratio of 20 to

Figure 4: GDP Growth Rates in the Immigration Paper
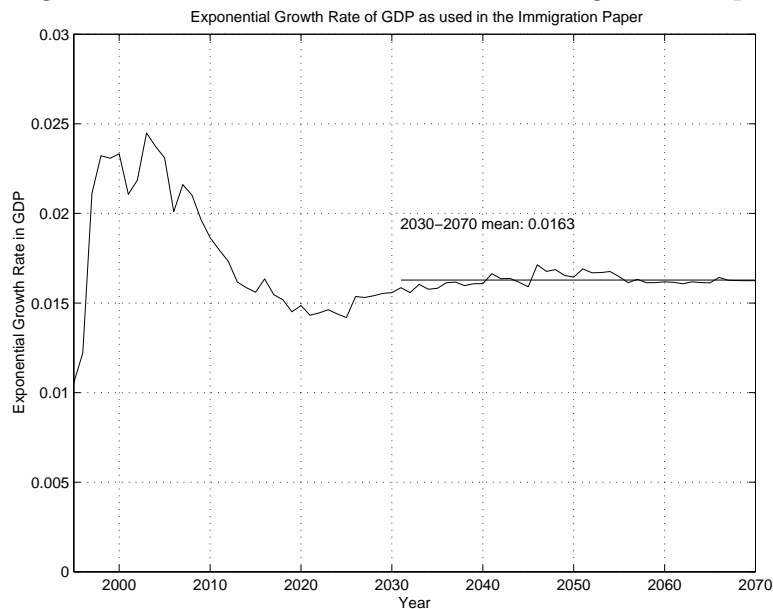
59 year-old people in our population projections to 20 to 59 year-old people in the CBO's population projections.

Figure 4 shows the time profile of the GDP series we used in the Immigration paper. The significant jumps in the beginning are due primarily to our reconstructing the series backward from 1996, which was the first year included in the CBO's dataset. The long-run trend settles down to 1.63% after 2030, a rather striking fact given that the CBO has now revised its estimates of GDP growth to reflect a long-term rate of 1.7%, as noted above. We had arrived at roughly that same figure on our own by scaling up the CBO's GDP measure by a crude relative labor force difference. Granted, the revision in the CBO forecasts was apparently centered on the capital stock, so it's probably just coincidence that our old figures more or less match their new ones.

We also present here the implicit exponential growth rates in the CBO's real GDP series for comparison. Figure 5 shows the annual trends, which culminate to roughly a 1.2% annual growth rate after 2030. A few notes on our derivation: the CBO figures were provided to us by John Sturrock, and they were in the form of nominal GDP totals for the years 1996 through 2070. We also obtained a price deflator series, with which we set nominal

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Figure 5: GDP Growth Rates in CBO Projections

Exponential Growth Rate of GDP as used by the CBO a year ago

2030–2070 mean: 0.0121
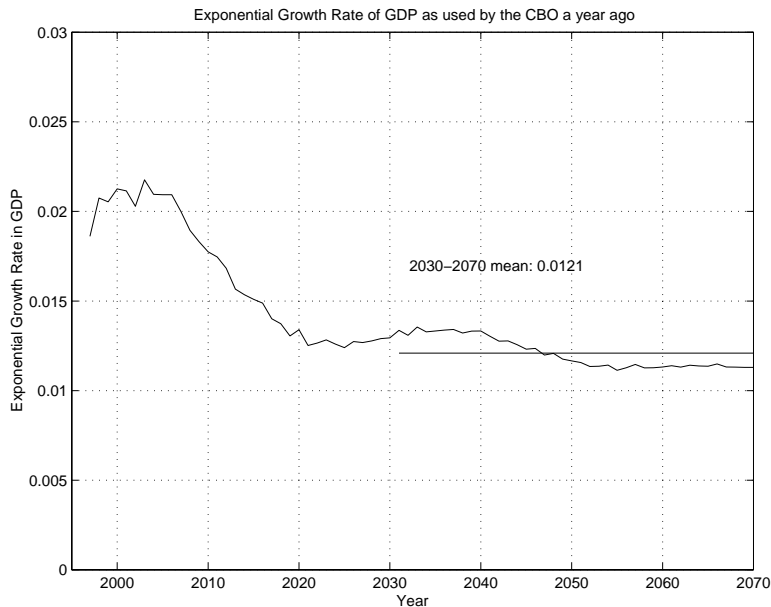
GDP in terms of 1994 dollars. The 1995 *Statistical Abstract* provided the level of 1994 GDP, and we created a value for GDP 1995 that coincided with the average annual growth rate between the 1994 and 1996 values.

3.2 Real interest

The real interest rate is projected just like the productivity rate:

$$r_t - \mu_r = \beta_r(r_{t-1} - \mu_r) + \epsilon_{r,t} \tag{5}$$

Here, μ_r is taken to be 0.03, the same long-run rate specified by the OASDI Trustees (alternative II) in the 1999 report. Fitting (5), we find $\sigma_\epsilon = 0.018$ and $\beta_r = 0.735$. These estimates were gleaned from historical data on the effective rate on bills held by Social Security, as well as historical data on three-month Treasury bills, after an array of specifications was investigated; see Bryan Lincoln's *notes.tex*. Inflation is purged through use of the historical CPI-U (urban consumers) index.

This short-run real interest rate is modeled as being completely independent of the level of indebtedness, an assumption that we think is fair

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considering the existence of endogenous budget rules that cap the growth of debt relative to income (see section 1).

We use this projected T-bill rate as a proxy for the interest rate earned on accumulated balances in the Social Security Trust Fund. As Foster (1994) points out, the true interest rate payable on new issues held by Social Security is actually the average yield on all outstanding Treasury securities whose maturities are over four years. The data series that Foster uses appears to be the historically recorded "special-issue" interest rates themselves. Comparing Foster's series since 1961 with a longer 3-month T-bill series (corrected for inflation) from 1939 indicates that there is little difference in levels or volatility between the two. That is to say, while our stochastic real interest might better model the effective rate on Trust Fund debt, it probably is acceptable to use such a rate to proxy short-term rates as well. Thus our short-run interest rate is the effective rate on Trust-Fund securities.

Another problem related to interest rates is how to calculate annual interest payments on a *stock* of debt that is financed at different rates. This topic is discussed further in appendix B. In our projections, we allow the entire Social Security Trust Fund to accumulate interest at exactly the short-run interest rate, while the rest of the federal debt held by the public accumulates interest according to a moving average of those rates. We derived weights according to the current term structure of the federal debt: 0.3 of the current year, 0.11 for each of the rates from 1 to 4 years in the past, 0.022 for 5 to 9 years, 0.003 for 10 to 19 years, and 0.012 for 20 to 30 years. The resulting effective interest rate on the stock of debt thus exhibits a more realistic level of volatility. This technique corresponds roughly to methods used by the CBO (1993).

An actuarial note by Kunkel (1997) may be useful in that it provides time series of the effective annual rates earned by the Trust Fund. That series could be compared in terms of volatility against the new-issue rate from Foster used by Lincoln. Since the relationship between the short-term rate and the effective rate is simply the relationship between marginal and average, the means of both series may well be comparable. For now, we maintain the simplifying assumption that the entire Trust Fund rolls over at the short-term, special-issue rate of interest, while federal debt held by the public earns an effective rate that is a moving average of the special-issue spot rate.

For simplicity, the state and local governments must pay the same effective interest rate owed by the US government, and their short-term rate is

also identical.

A final note on interest payments concerns yearly deficits: We assume that each year's deficit is accumulated at a constant rate, so that the total deficit accrues interest at half the annual rate. The rate used is the short-run interest rate, which for convenience is the special-issue rate.

4 Forecast methods: programs and growth over time

We categorize fiscal programs as either state and local or federal in nature. One big problem with treating state/local and federal as completely separate is that we fail to account for the uniquely joint natures of programs such as Medicaid and AFDC. That is to say, since we project each component separately, there is no scope for predicting the effects of block-grants or any other financing reform. For simplicity, state and local totals are aggregated across the fifty states into a single amount per each program. The federal and state and local budgets are assumed to be completely separate, running their own individual deficits or surpluses. Debt held by the public is subject to a universal effective real interest rate, as described above in section 3.2.

Fiscal programs at both the federal and the aggregated state and local level tend to grow in real terms through time, reflecting increasing demand for goods and services provided by the various levels of government. Broadly speaking, we model programs either as being "congestible" in a broad sense, or as public in nature.

Demand for congestible goods tends to respond when either population or income change. More people need more goods, and when real income rises, more congestible goods can be affordably consumed. Within this broad category we further differentiate between demographically driven programs and generic congestibles. The basic idea behind the growth paces of demographically driven programs is that program expenditures and receipts will maintain their basic age profiles and grow with the rate of per capita income growth, proxied by the productivity growth rate. An "age profile" corresponding to a demographically driven program is a starting-year vector showing real sums incurred by each age cohort. The elements of the age profile are derived from the BLS's Current Population Survey (CPS), and are scaled up so that the scalar product of the first year's cohort populations and the program's age

profile equals the starting-year total for that program. See appendix A for notational details.

Generic congestible goods grow at the rate of GDP, maintaining a constant share through time rather than fluctuating around GDP as age profiles might require. That is, demand for them tends to rise exactly in tandem with expanding populations and rising incomes.

Age profiles are a widely-used tool, but justifying their use relies on some key simplifications. We implicitly assume that the income distribution will remain the same in the future as it is now; even after years of economic growth fueled by productivity gains, dependency on poverty programs will not change. That is to say, as incomes rise by the productivity growth rate, the figurative "cut-off" for poverty programs rises at the same rate, implying that age profiles for such social programs shifts up by the same rate as well.

Social Security (OASDI) and Medicare (HI and SMI) are unique programs and are not accurately projected with age profiles and productivity growth alone. Following Lee and Tuljapurkar (1998), we project OASDI with complicated algorithms involving past earnings profiles, current retirees, and current tax receipts, among other elements. The Social Security system, with its own inflows through FICA, outflows, and Trust Fund, is subject to its own independent balancing, as described in section 2.3.

Projecting Medicare and Medicaid creates daunting tasks. The analysis is much more complicated than simple age profiles would imply. See appendices L and M for details.

We implement more rapid growth in Medicaid, HI, and SMI above and beyond the increase in per-capita wealth by adding nonstochastic bonuses to the productivity vector that measures the normal wealth effect. The nonstochastic vector is taken directly from the Immigration paper. Individual growth stimuli can be positive or negative. The stimuli are reported in table 2.

THIS NEEDS UPDATING. We allow for supernormal increases in the growth of Medicare and Medicaid outlays per enrollee in the short and medium term, following the CBO (1998). The average annual rate of "extra" growth in Medicare or Medicaid outlays per enrollee, meaning the growth above the growth in nominal GDP per work-hour (or labor productivity plus inflation), is listed as 2 percent over 1997–2008. We therefore assume a constant 2 percentage point growth stimulus above the rate of productivity growth during the years 1998–2008, followed by a period of linear decline from 2 percentage points in 2008 to zero in 2020, in line with CBO's 1998

assumptions.

Tax programs tied to capital earnings are also constrained to grow with the economy since we have assumed a fixed capital share of GDP through time. Other tax programs generally grow with age profiles.

Public goods, such as military expenditures, grow as constant shares of GDP. Generally speaking, demand for public goods does not rise directly in response to population pressures; a given amount of public goods is wholly adequate to a range of population levels. But as population expands, public goods become relatively cheaper in terms of national product because specialization and economies of scale free up new resources as they are obtained. As their relative price falls, the quantity of public goods demanded will rise—through the standard income and substitution effects—and we believe a net increase in the total outlays on public goods will result. A real-world example of this phenomenon is US space research; with fewer inhabitants, the country would likely find itself too preoccupied with other activities to advance those outlays. We therefore believe that expenditures on public goods will tend to keep pace with GDP, as the price effect tends to spur those outlays.

5 Federal control totals

The federal budget is forecast in its entirety, with all programs accounted for in some way.

5.1 Outlays

Control totals for federal expenditures are taken from the *Budget of the United States Government* for Fiscal Year 2000. The base year is 1998.

- **OASDI**: $383,561 in 1998 ($379,225m joint of benefits plus administrative costs ($3,648m), combined with $3,793m due to the Railroad Retirement financial interchange)

  from the US Budget, Item 650
- **HI** $136,690m in 1998

  from the US Budget, Item 570
- the earned income tax credit (**EITC**): $23,239m in 1998

  from the US Budget, Item 600
- expenditures on **K–12 education**: $15,120m in 1998

  from the US Budget, Item 500

- expenditures on **college education**: $785 in 1998

from the US Budget, Item 500

- the school lunch program (**child nutrition**): $8,556 in 1998

from the US Budget, Item 600

- **food stamps** plus WIC:[16] $24,043 in 1998

from the US Budget, Item 600

- **energy assistance**: $1,132m in 1998

from the US Budget, Item 600

- **direct student aid**: $11,162 in 1998

from the US Budget, Item 500

- **"public assistance"**: $30,046 in 1998

from the US Budget, Items 500, 600

- Supplemental Security Income (**SSI**): $27,472m in 1998

from the US Budget, Item 600

- unemployment insurance (**UI**): $22,070m in 1998

from the US Budget, Item 600

- **federal retirement** $43,464m in 1998

from the US Budget, Item 600

- **military retirement**: $31,142m in 1998

from the US Budget, Item 600

- **railroad retirement**: $4,239m in 1998

from the US Budget, Item 600

- **public housing**: $6,467m in 1998

from the US Budget, Item 600

- **rent subsidies**: $22,249m in 1998

from the US Budget, Item 600

- institutional **Medicaid** (25% of total): $25,309m in 1998

from US Budget, Item 550

- noninstitutional **Medicaid**: $75,925m in 1998

ibid.

- **incarceration costs**: $2,682m in 1998

from the US Budget, Item 750

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[16]We include WIC, the "special supplemental food program for women, infants, and children," in this total, thereby assuming WIC grows according to the same age profile as food stamps.

- **SMI** (Medicare Part B):[17] $55,523 in 1998
from the US Budget, Item 570 (HHS)
- **public goods**: $354,610 in 1998
- **congestible goods** : $103,707m in 1998
see below; all spending not accounted for elsewhere

As shown in the list above, Medicaid is divided into an institutionalized portion, which measures Medicaid payments to elderly Americans in institutions, and a noninstitutional portion. This distinction is also drawn at the state and local level. Medicaid is the only budgetary program for which we make allowance for differences between institutionalized and noninstitutionalized elderly. In all other respects, both types of citizens are assumed to have equal impacts within their age cohorts (see the discussion of age profiles below).

Congestible goods are calculated as a residual category, the remainder of total annual outlays once the sum of the other categories plus debt servicing obtained.

Public goods include the following categories from *The Statistical Abstract of the United States (1995)*: National defense; International affairs; Health research (a subcategory under Health); Veterans benefits and services; and General science, space, and technology. These categories totaled $346.4 billion in 1994.

5.2 Taxes

At the federal level, we aggregate taxes into six categories.
- **OASDI Taxes**: $429,218 in 1998 ($420,151m in payroll taxes plus $9,067m in benefit taxes)
from the US Budget, Analytical Perspectives
- **Personal income taxes**: $828,586m in 1998
from the US Budget
- **Corporate income taxes**: $188,677m in 1998
from the US Budget
- **Excise taxes**: $57,573m in 1998
from the US Budget

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[17]Since the unified federal budget follows the convention of including "user fees" such as the SMI contribution by individuals as offsets to outlays, we subtract the SMI contribution from SMI outlays to obtain this control total.

- **HI Taxes**: $119,863m in 1998
  from the US Budget
- **UI Taxes**: $27,484m in 1998
  from the US Budget
- **Other taxes**: $70,397m in 1998
  a residual category based on total taxes of $1,721,798m

A quarter of SMI expenditures is funded from contributions, so that quarter is counted as a separate revenue category. (The rest of SMI expenditures is funded directly from the budget.)

OASDI taxes and federal income taxes grow with the population and the economy in a manner identical to demographically driven expenditures. Corporate taxes and excise taxes are allowed to grow with the economy; since capital's share of output is the same through time, keeping a ceiling on average tax rates requires fixing those taxes at their income shares. Other taxes were assumed to remain the same in proportion to the sum of corporate taxes and excise taxes through time. One important note is that all non-OASDI federal taxes are considered equally fair game in reaching deficit targets, while the OASDI system is balanced on its own through tax hikes.

5.3 Totals

Total expenditures tallied $1,460,914m in 1994, of which $202,957m represented debt servicing on a stock of gross debt equal to $4,251,416m. Total taxes were $1,258,627m. Net of the OASDI system, spending and tax totals would be $1,137,892m and $908,761m, and with an initial balance of $436,385m in the OASDI Trust Fund, net debt would equal $3,815,031m.

6 State and local control totals

In describing the aggregate movements of state and local budgets, we referred to the *Statistical Abstract of the United States* and the Census Bureau's *Annual Survey of Government Finances*. Neither data source is sufficient on its own for our purposes; we need a detailed-enough level of aggregation to pick out individual programs, and the individual accounts in each source report control totals idiosyncratically in terms of aggregation. Data are reported for 1994 and earlier, so as necessary we inflate levels to 1994 values.

The budget concept at the state and local level is extremely different from its federal analogue. The Census Bureau splits its accounting into four categories: General, Utility, Liquor Store, and Insurance Trust. Most states have balanced budget provisions that apply to the general sector; the utility sector is heavily and consistently subsidized by state and local governments; liquor stores are frequently regulated; and insurance trusts are generally separate systems entirely. At the federal level, the unified budget concept includes inflows to and outflows from the vast majority of trust funds, and the general sector and the trusts are generally not sealed off from each other. We project the federal budget in the standard way, adhering to the unified budget principle; but at the state and local level we are primarily concerned with the general sector plus utilities and trusts, since the insurance trusts are virtually fully funded and separate from the rest of the government. See the related appendices for details.

Expenditures on capital goods is accounted for separately by the Census Bureau at the state and local level, but we elect to treat capital goods and consumer goods identically. Ideally, we would model them separately, since the decision to purchase capital goods will be influenced by demographic pressures and expectations much differently.

Transfers from the federal government to the states are netted out of the figures. Likewise, we remove the theoretical fiscal impact of corporations in order to avoid projecting the benefit stream absorbed by non-citizens over time. Property taxes are split between renters and homeowners.

6.1 Outlays

The general sector programs that we forecast consist of the following:
- institutional **Medicaid**: $19,457m in 1998
- noninstitutional **Medicaid**: $58,371m in 1998

from www.hcfa.gov; 75% of state and local total
- Supplemental Security Income (**SSI**): $4,121m in 1998
- **"public assistance"**: $20,944m in 1998
- **food stamps**: $1,410m in 1998
- expenditures on **K–12 education**: $295,425m in 1998
- **public college** funding: $56,916m in 1998
- **incarceration costs** $43,177m in 1998
- **congestible goods** $315,236 in 1998

a residual

Congestible goods are a residual category derived from total direct expenditures minus the totals for programs already enumerated, minus federal contributions, minus interest payments, minus fees for utilities,[18] and minus total taxes paid by corporations. We believe corporate taxes are directly offset by state and local outlays directed toward corporations, so to account for all "net of corporations" outlays, we subtract a measure of those expenditures on corporations. (See the following section on taxes for a discussion of why we purposefully omit corporations from our calculations.)

6.2 Taxes

State and local taxes are estimated using the Census Bureau's State and Local Government Finance Estimates, which contains totals through FY1996. Numbers for 1998 are estimated based on average annual growth rates over the period 1992–1996 or 1993-1996, depending on the availability of the series in the required aggregation.

- **state personal income taxes**: $165,057m in 1998
- **property taxes**, home: $99,108m in 1998
- **property taxes**, rentals $33,389m in 1998

36% of 70% of total property taxes

- **sales taxes** (noncorporate) $181,568m in 1998
- **other taxes**: $334,625m in 1998

a residual

It is our belief that states compete with their fiscal policies in order to lure corporations across state borders.[19] We also assume that there "enough" states whose locations are perfect substitutes, or who compete on net price in a Bertrandian fashion. That is, the equilibrium net price that corporations pay in return for operating within state borders is exactly equal to the cost incurred by the state. State expenditures on corporations therefore exactly offset state taxes on corporations, because otherwise some state could undercut the competition and lure corporations away, enjoying a windfall (but temporary) profit. A similar argument does not hold at the federal level; there is only one federal government that holds monopoly power.

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[18]We believe that subsidies to utilities, the surplus of expenditures over tax collections, should be counted as congestible goods. So we subtract the tax collections and end up with a net subsidy.

[19]See Clune (1995) for details.

We therefore net out the fiscal impact of corporations from the state and local analysis, using the pivotal assumption that every corporate tax is exactly picked up by expenditures. Corporate income taxes are one category of taxation that we imagine is balanced by targeted expenditures. Secondly, we assume corporations pay 41.5% of total property taxes (California Board of Equalization, 1995). Thirdly, we believe corporations pay 35% of sales taxes (Sheffrin and Dresch, 1995). We therefore subtract those numbers from the totals on both the receipt and expenditure sides.

Of the 58.5% of property taxes not paid by corporations, we assume 36% represents taxes on rental property.[20] Of that subtotal, we assume 70% is borne by renters (and categorized as "property taxes, rentals").[21] The other 30% is assumed to be incident on landlords, and it is included, along with the remaining 64% of property taxes not paid by corporations, in "property taxes, home."

6.3   Totals

Data on receipts and expenditures at the state and local level do not provide as clear a picture of net flows as data on changes in debt do. Ignoring the paths of debt and assets, a simple enumeration of inflows and outflows would indicate that debt is being paid down at a fast rate, since a large primary surplus results. But timeseries data on net debt relative to GDP show a roughly stable 3% path, suggesting some kind of measurment error that makes receipts appear too high relative to expenditures.

We choose to estimate the required primary deficit that would keep state and local net debt to GDP fixed at 3% over 1997 to 1998 (the base period), and we adjust expenditures upward by the required amount. Since expenditures are already being adjusted downward by the amount of federal transfers to the state and local sector, we feel it is appropriate to assume the measurement error is occurring on the spending side. But another possibility is that our assumptions concerning corporate taxation are not quite right.[22]

Total current noncorporate, nonfederal, noninterest outlays outside of the utility, liquor, and insurance trust sector made by state and local governments

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[20]California estimate cited by Clune

[21]This figure is provided by Robert Inman.

[22]This seems unlikely, though; for this to explain the spending shortfall, it would have to be the case that corporations absorbed more in spending than they gave in taxes. If anything were to cause a departure from a zero net effect, it would probably be the reverse.

in 1998 are estimated to be $850,663m Interest payments are $60,831m. Receipts in this sector for 1998 are estimated at $844,504m. Interest income is $58,747m.

Debt outstanding is estimated at $1,284,762m in 1998, while cash and security holdings other than in trust funds are projected at $1,026,197m. Net debt is therefore $258,592m, or about 3% of FY98 GDP, $8,635,000m. For our purposes, we need FY97 debt as a launch point. Assuming the 3% level, FY97 debt is $245,447m.

A Calculating fiscal projections using a convenient matrix notation

A.1 Finding aggregate totals

We represent the matrix of population projections for each sex as P_n, where the n subscript indexes the specific run out of a sample of 750. Each P_n is 76×22, reflecting the 76 years implicit in the 16-element projection of five year increments and the 22 age cohorts in each year. Each element $p_{i,j}$ is the number of members of age cohort j in year i.

$$P_n = \begin{pmatrix} p_{1,1} & p_{1,2} & ... & p_{1,22} \\ p_{2,1} & p_{2,2} & ... & p_{2,22} \\ ... & ... & p_{i,j} & ... \\ p_{76,1} & ... & ... & p_{76,22} \end{pmatrix} \tag{6}$$

Each program covered in the projections impacts fiscal balances according to an age profile, a vector of fiscal amounts that the average members of each age cohort incurs in the base year. This age profile is constructed using CPS data assigned between the sexes and ages that are scaled up to fit the starting-year totals found in aggregate sources. Thus the profile $\vec{v}_\phi$ for program ϕ, sex female, and run n is a vector of 22 elements for which:

$$\vec{v}_\phi = c\vec{\omega}_\phi, \tag{7}$$

where the first-year calibration is fixed by:

$$c\vec{\omega}_\phi \cdot \vec{p}_{1,n} + c\vec{\omega}_\phi^m \cdot \vec{p}_{1,n}^m = \tau_{1,\phi}, \tag{8}$$

in which c is the constant scaling factor that reconciles the CPS-derived raw age profiles for males and female, $\vec{\omega}_\phi$ and $\vec{\omega}_\phi^m$, with the empirical total for

the first year, $\tau_{1,\phi}$; and $\vec{p}_{1,n}$ and $\vec{p}_{1,n}^m$ are the first-year population vectors in run n, or the top row vectors in the female and male versions of (6). (Note: currently, our first year is stochastic, not fixed.)

We construct the 22×22 matrix V_ϕ so that along its main diagonal the values v_j represent the amount incurred by the average member of age cohort j in the base year under program ϕ.

$$V_\phi = \begin{pmatrix} v_1 & 0 & ... & 0 \\ 0 & v_2 & ... & 0 \\ ... & ... & v_j & ... \\ 0 & ... & ... & v_{22} \end{pmatrix} \tag{9}$$

The age profiles grow each year to keep pace with rising wealth. Per capita income grows at the productivity growth rate, g_i in year i, so productivity growth is a reasonable proxy for the growth rate of wealth. Therefore we represent the cumulative growth of v_j by time i as γ_i, where $\gamma_i = \Pi_i(1 + g_i)$. Note that we'll keep $\gamma_1 = 1$, so that g_i is actually the rate of productivity growth between i and $i + 1$. We represent cumulative growth rates in the diagonal matrix G, which is 76×76:

$$G = \begin{pmatrix} \gamma_1 & 0 & ... & 0 \\ 0 & \gamma_2 & ... & 0 \\ ... & ... & \gamma_i & ... \\ 0 & ... & ... & \gamma_{76} \end{pmatrix} \tag{10}$$

It follows that $\gamma_i p_{i,j} v_j$ is the appropriate measure of the total amount incurred under program ϕ by cohort j in year i. The 76×22 matrix product GP_nV_ϕ contains these figures:

$$GP_nV_\phi = \begin{pmatrix} \gamma_1 p_{1,1} v_1 & \gamma_1 p_{1,2} v_2 & ... & \gamma_1 p_{1,22} v_{22} \\ \gamma_2 p_{2,1} v_1 & \gamma_2 p_{2,2} v_2 & ... & \gamma_2 p_{2,22} v_{22} \\ ... & ... & \gamma_i p_{i,j} v_j & ... \\ \gamma_{76} p_{76,1} v_{22} & ... & ... & \gamma_{76} p_{76,22} v_{22} \end{pmatrix} \tag{11}$$

The product of GP_nV_ϕ and a 22×1 summer vector will yield a column vector showing the total amount incurred by all cohorts for program ϕ in each year in run n. Since the two sexes are modeled separately in the population projections, the total measure T_ϕ is:

$$T_{\phi,n} = GP_nV_\phi + GP_n^m V_\phi^m \tag{12}$$

30

where P_n^m is taken to be the male population matrix in run n. Likewise, V_ϕ^m is used to represent age profiles for males. It could be the same or different than its female counterpart for program ϕ.

A.2   Recovering cohort accounts

For computational efficiency, fiscal totals are aggregated across cohorts during the projection process. Once they have been adjusted to conform to the appropriate budget criterion, we recover the cohort accounts by applying the previous process in reverse. Following (8), we first recover the gender-specific accounts by taking the appropriate share of the total:

$$g_{i,\phi}^m = \frac{\vec{\omega}_\phi^m \cdot \vec{p}_{i,n}^m}{\vec{\omega}_\phi \cdot \vec{p}_{i,n} + \vec{\omega}_\phi^m \cdot \vec{p}_{i,n}^m} \cdot \tau_{i,\phi}, \tag{13}$$

where the variables are the same as before, except that $g_{i,\phi}^m$ refers to the total in year i assigned to males. (Notice the scaling factor c cancels everywhere.)

The cohort accounts can be recovered by calculating the proportion of each sex-specific account that is assigned to each cohort. Let ω_j^m be the element of the raw age profile $\vec{\omega}_\phi^m$ corresponding to male cohort j. Then:

$$a_{i,j,n}^m = \frac{\omega_j^m p_{i,j,n}^m}{\vec{\omega}_\phi^m \cdot \vec{p}_{i,n}^m} g_{i,\phi}^m, \tag{14}$$

where $a_{i,j,n}^m$ is the cohort account number for male cohort j in year i and run n. Similar formulae applies for females. For programs without age profiles — i.e., programs that grow as fixed shares of the economy — totals are assigned equally to each age cohort. Mechanically, this means replacing the age profiles ω with a vector of ones.

B   Debt growth regimes

Since our model incorporates a stochastic model of the real interest rate, structuring the growth of real debt is no longer a moot point. In other long-term projections such as those of the CBO, real interest rates are fixed in a static "high," "medium," or "low" regime. It doesn't matter in such a model whether the entire federal debt is compounded each year or in different years according to its term structure, because the real interest rate is fixed

throughout time. When the real interest rate fluctuates each year, there is a computational difference between conveniently rolling the whole debt over each year and rolling over appropriate portions of the debt as they come due.

Currently, we use a moving average of past interest rate projections to simulate a more realistic rolling-over of the aggregate stock of debt. See section 3.2.

C   Incarceration

It seems logical that there should be a definite age structure to criminal activity and incarceration. Therefore modeling incarceration costs with age profiles would be more realistic; we would tend to expect that if there are relatively more older people in future populations, total incarceration rates would fall. One issue that arises is whether we should treat prisoners as a stock or as a flow variable, however. Analysis based on age profiles tends to treat people as a flow insofar as x year olds incur expenses assigned to $x + 1$ year olds (times the income inflation factor) after a year passes. But prisoners—more like a stock—aren't thrown back in with the unincarcerated population each year, while normally aging noninstitutionalized people are mostly homogenous. While it could be the case that the age structure of prison inmates remains the same year-by-year, it isn't as intuitively obvious why such a pattern should obtain.

Recent data on state inmates from the Stat Abstract (Tables 14, 333, and 351) seems to show some stock characteristics in the age distribution of inmates. However, when inmates populations are compared with their age cohorts in the general population, it isn't clear whether a stock concept is superior to a flow due to the across-the board increases in incarceration rates.

Table 3 shows how inmate populations have behaved more like a stock in terms of their age distribution. Younger inmates have become older; age groups 35–44 and older have gained in proportion to the other cohorts, while the 18–24 cohort has shrunk in relative terms. The 25–34 cohort has retained roughly the same share.

The data in table 4 aren't all that compelling, since for tracking incarceration rate growth, it would be better to have at least 3 data points rather than two. The figures show a crude estimate of incarceration rates, derived by dividing the incarceration totals by the population totals in each year as given in the Stat Abstract. (Prisoners under 18 are assumed to be comparable to

the 15–19 age cohort, and the 18–24 age bin is divided by the 20–24 population bin.) If we throw out the smallest groups, the statistics show that the middle cohorts experience across-the board increases in incarceration rates of roughly a factor of one-half.

Analysis based on a fixed age profile would overlook the growth in these incarceration rates. Furthermore, it isn't clear why the age of the inmate should matter in determining the costs of incarceration. Obviously if incarceration costs were determined only on the basis of the number of warm bodies in prisons, there would be no distinction. A more appropriate modeling method might therefore be to forecast incarceration rates and prison populations (stock) and assign a cost to each prison inmate that rises with productivity.

While the use of age profiles seems incorrect here, forecasting prison populations is also beyond the scope of this report. If incarceration were treated as a generic congestible good, however, perhaps we might avoid the stock-flow pitfalls of using age profiles while still maintaining some realism without resorting to a full-blown projection of prison populations.

A congestible-goods argument might proceed as follows: As the population grows, a larger number of people will commit crimes, as both the pools of prospective victims and prospective criminals increase in size. As income rises also, there will be a tendency for people in the lower reaches of the income distribution to commit crimes, and there will be a growing array of goods that are targeted for theft and crime. Thus we believe that a constant share of income, growing with respect to demographic forces and productivity, will be devoted to correctional activities as criminal activity grows with the economy. As the population ages, there would be no "decriminalizing" side-effect; perhaps even though there are relatively fewer people of incarcerated ages, the abundance of older, more vulnerable Americans provides more opportunities for crime.

While the congestible-goods argument is appealing, recent trends in incarceration expenditures do not offer unequivocal support. It depends which time period we take as our base; table 5 shows the growth rates in real state expenditures on corrections and the shares of real GDP taken up by these outlays over the years 1982 to 1992. These data were taken from the *Statistical Abstract*. Nominal flows were converted to real with the implicit GDP deflator (Table 685). As is clear from the numbers, real expenditures seem to be growing faster than real income, although a possible slowdown is apparent toward the end of the time series. Still, the total percentages remain below

one-half of one percent. Growth in nominal state expenditures according to the Stat Ab (Table 333) is given in table 6.

Table 7 reports nominal spending on corrections according to the Census Bureau's State and Local Government Finances Estimates,[23] alongside nominal *fiscal year* GDP estimates from the Bureau of Economic Analysis, acquired via the Stat-USA web-site. Fiscal year estimates were constructed as the geometric averages of the relevant quarterly seasonally adjusted annual rates. Nominal corrections spending is recorded according to the states' fiscal years, which do not necessarily overlap. So the comparison should be regarded as an approximate one.

Capital expenditures are included in the Census Bureau's measures, but are not large relative to the rest of the category, on the order of 8–10% of the total. With capital spending included, corrections total about 0.5% of GDP, per table 7, while without them they're roughly 0.45%.

As is evident from the data, there was a substantial slowdown over 1993 and 1994 in the explosion of state and local incarceration costs from the preceding decade. Most likely, the trend in the 1980s and early 1990s was due to secular shifts in law enforcement practices and crime; now that the system has equilibrated at its new level, costs are maintaining a constant share of the economy, roughly

Assuming corrections costs of 0.5% of GDP, we find a starting value of $0.005 \times \$8,635.4 = \$43.177$ billion in 1998, where fiscal year GDP in 1998 was $8,635.4 billion, according to Stat-USA.

We project incarceration as a congestible good that grows with the economy.

D State and local education & property taxes

In forecasting state and local educational expenditures and property taxes, the question arises as to whether the two should be linked or decoupled. Schools are largely funded through property taxes as a rule of thumb, so it is conceivable that educational expenditures could drive the level of property taxes.

There isn't much readily available evidence on the topic. Figure 6 depicts on a logarithmic scale the paths of (nominal) property taxes, state and local

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[23]As of early December 1999, these figures are located on the web at http://www.census.gov/govs/www/estimate.html

Figure 6: Property Taxes, Education Spending, and Local Revenue

S&L Property taxes (–), K–12 Outlays (x), Total Revenue (o)
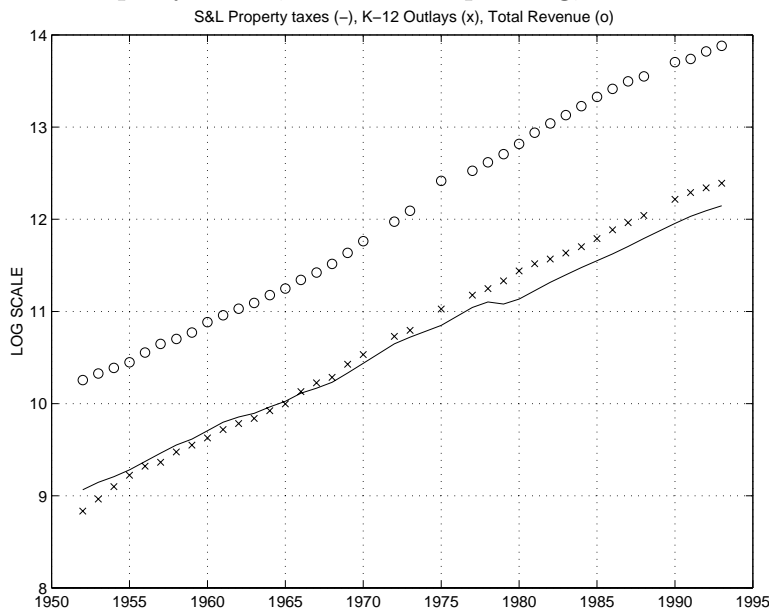
K–12 expenditures, and state and local tax revenues (not including federal transfers) from historical data.[24] The path of log property taxes is pretty clearly at a lower trajectory than the other two series, suggesting that property taxes do not tend to rise directly with educational costs. Further, it appears that the trajectories of log educational costs and log total revenue are roughly parallel. This might suggest that educational costs are more closely linked with *total* state and local revenues than with property taxes alone.

Nevertheless, it seems to make the most intuitive sense to project property taxes as growing one-for-one with K–12 costs. We thus use a K–12 age profile, productivity growth, and an appropriate scaling factor to forecast property taxes.

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[24]See Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970*, series Y 505–521, 655; and *Statistical Abstract of the United States*, various years; Nos. 470 (1994), 456 (1992), 462 (1990), 453 (1989), 437 (1988), 442 and 452 (1986), 468 and 479 (1981), and 424 (1975).

E   Federal education spending

Federal data on educational outlays is much easier to come by than their state and local counterparts, but an additional complication arises.[25] Levels of expenditures on elementary and primary schools are unambiguous for the most part, but where postsecondary education is concerned, accounting for federal *loans* to students becomes a topic of concern.

The bulk of student loans have historically been issued under the Federal Family Education Loan (FFEL), which procured capital from the private sector and extended that credit to students. Naturally, the present value of such a loan wouldn't be included in the government's balances, since ownership of the asset resided in the private sector. On-budget outlays involving those loans were restricted to interest payment subsidies while the borrower was still in school, special allowances sometimes paid to lenders, and bailouts for loan defaults.

The Student Loan Reform Act of 1993 changed the picture considerably, shifting some of the default costs to states, guaranty agencies, and loan holders. More importantly, the Federal Direct Student Loan program (FDSL) (also called Ford Direct Loans) was created ultimately to take over all the functions of the FFEL. The FDSL's capital is provided directly by the Treasury, which borrows funds through bond-issue and loans them to students. Outstanding loan totals are strictly off-budget even under the new FDSL system, and on-budget items include only the administrative costs, interest subsidies, and default bailouts.

Assuming there is no windfall change in student borrowing and repayment habits, the current system will remain stable through time and won't drag resources away from general revenue. On-budget items are more or less pure subsidies and represent one-time expenditures just like other budget items. Therefore we model direct student loans in exactly the same manner as other programs; annual totals shift with age-specific population changes and productivity, and there is no payback effect.

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[25] A good reference for this section is Charlene Hoffman, "Federal Support for Education, Fiscal Years 1980 to 1996," NCES 97384 (GPO 065-000-00958-7), 27 December, 1996.

F   Unemployment Insurance

The difficulties in projecting joint programs between the federal and state and local levels are particularly trying in the case of unemployment insurance. Not only are the structures of financing and expenditure themselves complicated, with many confusing intersections between federal and regional funds, the business-cycle fluctuations that create the dynamics of the system compound the difficulty involved in forecasting.

The Unemployment Compensation (UC) system is linked to the Social Security Act and other welfare programs of the New Deal.[26] All UC money is channeled through the Unemployment Trust Fund, which is managed by the US Treasury and included in the unified federal budget much as the Social Security and Medicare trust funds are. Receipts are collected through taxes on employers; the lion's share of these taxes, based on employees' wages up to a certain cutoff, are collected directly by the states and deposited in the Trust Fund. Employers (or states) whose UC plans are in accordance with federal regulations are granted exemption to most of the Federal Unemployment Tax (FUTA tax), but a small percentage is collected directly by the FUTA tax and used mostly to fund administrative costs.[27]

States have their own earmarked pools of contributions to the trust fund, and they draw them down individually as outlays are required to meet unemployment claims by laid-off workers. Since Unemployment Compensation is technically an entitlement, states are legally required to provide benefits to those citizens who qualify. States who can't meet their obligations may borrow from the federal government, but those loans must eventually be re-

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[26]For references, see Blaustein (1993) and Rubin (1983).

[27]In the appendix section of the 1998 budget dedicated to the Department of Labor (DOL), there is an official description of how the funds flow (p. 715):

"The financial transactions of the Federal-State and railroad unemployment insurance systems are made through the Unemployment Trust Fund. All State and Federal unemployment tax receipts are deposited in the trust fund and invested in Government securities until needed for benefit payments or administrative costs. States may receive repayable advances from the fund when their balances in the fund are insufficient to pay benefits. The fund may receive payable advances from the general fund when it has insufficient balances to make advances to States or to pay the Federal share of extended benefits.

"State payroll taxes pay for all regular State benefits. During periods of high State unemployment, extended benefits, financed one-half by State payroll taxes and one-half by the Federal unemployment payroll tax, are also paid. The Federal tax pays the costs of Federal and State administration of the unemployment insurance and veterans unemployment services and 97% of the costs of the employment service."

paid with interest. As pointed out in the UC chapter of the House Ways and Means Committee's *Green Book*, the political and economic repercussions of having to borrow to meet UC obligations are nontrivial; a forced Unemployment Tax hike would likely result, depressing the local economy and endangering the political careers of state officials (1996: 350). It is likely that states face palpable incentives to keep their UC obligations funded to a reasonable degree.

History suggests that the system is far from always being in balance, however. The federal government has routinely bailed out the trust fund during periods of high unemployment, most recently during the downturn of the early 1990s. The bailout usually takes the form of a special Ways and Means bill that provides extended benefits to the unemployed; for example, the Emergency Unemployment Compensation Act of 1991 provided money for an additional 26 to 33 weeks of benefits to be distributed after the usual 26-week periods covered by state insurance had come to an end. Federal expenditures as reported by the *Green Book* on extended benefits plus supplemental benefits ballooned from $30m and $10m in 1990 and 1991 to $11.15bn, $13.17bn, and $4.37bn in 1992, 1993, and 1994 (1996: 330). Part of that tremendous increase was due to a one-time shock associated with an eligibility reclassification, but the sheer magnitudes still demonstrate the volatile nature of federal spending on UC.

Currently, however, the program is in surplus; federal UI receipts totaled about $27 billion in 1998[28], while UI outlays were about $19 billion, plus roughly $2 billion in administrative costs. The robust expansion of the 1990s and the low unemployment it has fostered are undoubtedly behind the program surpluses.

Our projections make no attempt to model recessions and expansions, however. Were the economy to shrink, UC outlays by the federal government would expand in the same way that tax receipts would surely fall as part of the natural braking mechanisms that federal fiscal policy exhibits. Likewise, when times are good, the federal coffers would most likely be filled with surplus FUTA tax revenue. It behooves us to chart a "middle road" for the projections that takes into account these countervailing effects of business cycles over time.

As with other programs, we could theoretically use age profiles and the productivity growth rate to capture the demographic and wealth changes

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[28]*Analytical Perspectives*, FY 2000, p. 90.

through time that we think might determine the path of UC expenditures. The CPS reports a measure of unemployment compensation that can be used to proxy the age profile of UC expenditures, but since UC taxes are collected at the employer level, we have no analogue for the funding side.

The UC system is partly designed to equilibrate outlays and receipts endogenously. Taxes collected at the state level are subject to "experience rating," a system by which employers are taxed according to the historical trend of UC claims by their own former employees. In order to avoid getting hit with a higher tax through the system of experience rating, therefore, firms may elect to lay off fewer workers. In practice, however, there is little evidence of a substantial braking effect. Thus while it is likely that due to the structure of the system taxes will tend to rise when expenditures rise, it isn't clear that this actually happens. Experience rating is probably better described as a system in which risk is pooled across companies instead of through time (cross-sectionally rather than logitudinally). Therefore while experience rating probably implies that in any given year UC will be fully funded, there is no such implication for the system's finances through time.

The path of UC taxes collected is likely to follow the path of earnings, so with a general idea of how demographics and wealth will shift UC benefits and earnings over time, we might be able to say more about the likely financial balance in the UC system. Figure 7 shows the overlapping age profiles of UC benefits and earned income for men and women. The distribution of UC across age bins is flatter and more heavily weighted toward younger workers, especially for men. This seems to suggest that UC is a form of wealth redistribution from older workers to younger workers, if we make the simplifying assumption that UC is funded with a simple proportional tax on earned income.

If this is the case, then as the population ages and there come to be relatively fewer younger workers per older worker, we'd expect to see UC benefits drop. Under such circumstances, it would be hard to imagine UC taxes maintaining some kind of exogenous level. Rather, it seems much more likely that taxes would fall in tandem. It would be problematic for our analysis were benefits projected to rise in relation to the probable tax base, since tax hikes to meet obligations are only plausible within a given range; but since pressures are likely to subside, it is realistic to expect the system roughly to balance.

In summary, UC is clearly not a fully funded system in the strict sense, but it appears that it would be a reasonable assumption to limit federal li-

Figure 7: UC Benefits and Earned Income Age Profiles

Unemployment Compensation (+,−) and Earned Income (o,x) Age Profiles
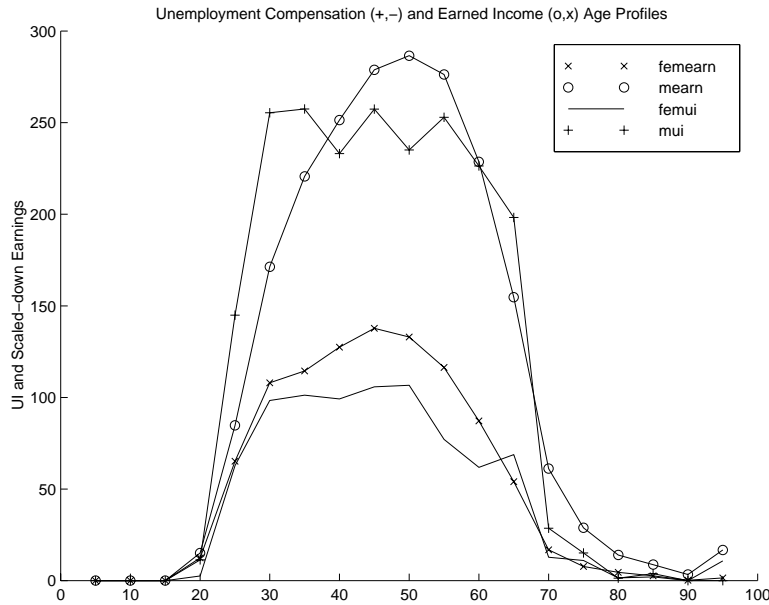
abilities at a relatively low level, reflecting the "average" liability through business cycles. The consequences of experience rating, the age profile of benefits in proportion to the tax base, the implications of UI insolvency for state governments, and the moderating influence of federal fiscal policy on business cycles all suggest a relatively stable average trajectory of federal support for UC. We then model the state and local side as if it were fully funded; we believe taxes and benefits will tend to equalize through time due to aging of the workforce and the incentives of experience rating. We ignore the trust fund dynamics (since we currently do not model unemployment) — we might implicitly assign $22,706m in equal UC taxes and expenditures to the states, so that their individual UC accounts remain perfectly balanced through time but rise or shrink according to the age profile of benefits.[29]

[29]Disaggregated data available in Blaustein matches data in the *Statistical Abstract* for the state and local level, but unfortunately the time periods covered are not ideal. The Stat Ab lists state and local expenditures on "Unemployment Insurance and employment services" as being $13,919m in 1980 (Table 573), while Blaustein sets "Total regular benefit outlays" at $13,768m in the same year. Federal outlays are reported as $4,408m for that year in the Stat Ab, which would be roughly one percent of the "Total taxable payrolls" listed by Blaustein as being $458.6bn in 1980. Outlays are exactly three percent of that

These flow variables do not concern us vis-a-vis budget balance, but they would matter if we were to construct generational accounts based on net taxes and transfers. The federal budget reports that administrative UC expenses were \$2,403m in 1994. These outlays are projected to grow as other congestible goods do: with the economy. Likewise, we assume that the FUTA tax remains a constant share of GDP as well.

Thus we project the federal share of UC expenses as congestible administrative costs, being funded from general revenue. The state share — consisting of the UI benefits themselves — is considered fully funded and therefore invisible.

THIS NEEDS UPDATING. We project both sides of the UI system (spending and revenue) based on the unemployment compensation age profile, scaled with productivity growth and the initial 1998 levels of spending and revenue. The UI trust fund is netted out of the gross federal debt to yield a measure of net debt. The system runs \$5 billion (grown at productivity and population) surpluses.

G   Workers' Compensation

The nature of the Workers' Compensation (WC) systems in the state and local sector is very similar to Unemployment Insurance, but WC is much closer to a system of *insurance* in the strictest sense for a government program. In order to expedite claims in response to work-related injuries, the

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total, while state taxes collected are given as about 2.5 percent.

The Employment and Training Administration, a section of the US Department of Labor, has published recent statistics in the form of graphics online(www.itsc.state.md.us/UI; specifically /chartbook/national/96/cover2.htm). Data for 1996 indicate that tax collections in FY1996 were \$22.7bn (79%) at the state level and \$5.9bn (21%) at the federal level, all of which were collected under the FUTA.

The Labor Department's breakdowns in the federal budget (p. 715) display figures that correspond to those cited by the ETA. The DOL lists a total cash inflow from federal and state sources of \$28.6bn in 1996. According to the DOL, the total balance of the fund at the start of 1996 was \$47,858m. Total cash income was \$32,398m, of which \$22,706m represented deposits by states into their accounts in the Unemployment Trust Fund; \$5,854m came from general taxes and the FUTA; \$24m was deposited by the Railroad Retirement Board; \$599m was deposited by federal agencies through the Federal Employees Compensation Account; and \$3,373m came in as interest and profits on investments. Cash outflows totaled \$26,228m in 1996, of which all but \$82m (railroad UC) went out of the Unemployment Trust Fund. At the end of the year, the trust fund balance was \$54,028m.

WC system is structured so as to reduce the impediment of litigation; workers and employers are insured against injuries to workers on a relatively equal footing.[30]

The vast majority of states (47) require some form of WC, but one large operational difference between WC and other social programs is that WC insurance funds need not be managed directly by the states. Employers may elect to self-insure by setting aside assets, to purchase policies from private insurers, or to participate in state-managed insurance programs. The last of these only accounted for between a quarter and a fifth of all WC benefits paid at the end of the 1970s (Darling-Hammond and Kniesner, xv), and there has been no sign of any trend since.

Prices of all WC policies are regulated by the states, however. The more persistent component of WC benefits, periodic wage replacements, are determined by states on the basis of the current averages of their statewide nominal wages. By law, the system is fully funded to the extent that whenever an accident occurs, employers or insurers must set aside funds to meet the *entire* future expected stream of benefit payments (Worrall and Durbin 586). State actuaries are left to determine the prices of the WC policies in order to plan for such eventualities; they will find the discounted present value of all expected future payment streams and price policies accordingly, reevaluating when information becomes known.

While the state-managed WC funds must meet liabilities of the state and its localities in their capacities as employers, the bulk of state fund outlays is made on behalf of the private employers electing to take part in the state insurance fund. Likewise, the majority of inflows is earmarked for private-sector employees. In determining the liabilities of the state and local government sector with regards to WC, only the costs of purchasing and paying premia on own-worker policies should be considered; the state would likely never be liable for anything beyond the costs of maintaining policies for its own employees (and possibly the administration costs associated with the fund). If funds for covering private-sector employees were short, it could simply raise the prices of WC policies if set-asides by the private sector were themselves insufficient.

It is technically infeasible to extract just the contributions of and benefits to state and local employees from the aggregate numbers reported by the

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[30]The references for this section are Worrall and Durbin (1996) and Darling-Hammond and Kniesner (1980).

Census Bureau (which typically show total contributions to the WC funds). The only reason we might want to is that since their employers are governments themselves, outlays will not generally be matched by inflows. As in the case of Unemployment Compensation, however, the effect of this simplification is small, and there is evidence that payrolls, already forecast, would adjust anyway. (See appendices F and H.)

We believe there to be balance inherent in the system; the fully funded nature of obligations to injured workers and the actuarial method of setting insurance prices naturally create a system that is self-sustaining without any kind of PAYGO assistance from state and local governments. (The same cannot be said for other social insurance, such as federal retirement programs.) Workers' Compensation is therefore modeled as a fully funded program, and we drop benefit payouts from and inflows to the state and local WC funds from consideration.

H   Benefits and total compensation

In the case of social insurance programs that are more or less administered through employers, namely Workers' Compensation or Unemployment Compensation, the salient question of cost incidence arises when government employees are the end recipients.

For example, we have profiles of UC and WC benefits, which we would usually interpret to be the age-specific outflows from the insurance funds. These represent total benefit payouts from the funds, not contributions on behalf of state and local employees; we have no model of the financing necessary to back those contributions. A key question is whether costs of providing benefits such as WC (and by extension those of other programs) are merely absorbed by firms, passed on to workers in the form of lower pre-benefit wages, or both.

If costs are passed on to workers completely, then state and local governments would merely dip into their payrolls — congestible goods expenditures — to fund WC policies by decreasing wages paid to their employees. We would project WC funding as a (possibly changing) proportion of congestible goods expenditure. This could conceivably create a problem if we were to believe that WC funding is determined according to an age profile that implies explosive growth; it can't be the case that WC takes up more than a reasonable share of congestible expenditures. The difficulty in ruling

Figure 8: Workers' Comp Age Profile

Workers Compensation Payments
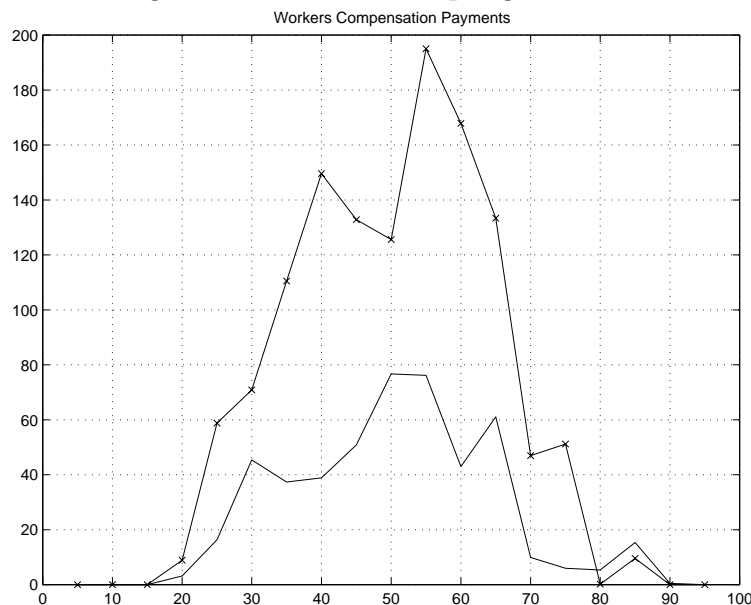
out that kind of scenario is apparent when we look at the age profile of WC benefits derived from CPS data (figure 8). Since it peaks at a relatively old age bin (50–55), it's hard to say what should happen to WC over time as the population ages. There may be comparatively more 50–55 year-olds, health care costs may rise, or work may somehow become more safe (the types of jobs Americans hold may change, or the technology improvements might enhance job safety). These particular effects countervail. Needless to say, the age-patterns of employment may also be changing over time, although we have assumed such trends do not occur (see section 2.1).

If costs were borne entirely by employers, then funds earmarked for UC and WC pools would grow separately from congestible expenditures on the state and local public sector wage bill. We have no good way of modeling how the states and localities might collect some kind of WC/UC tax on themselves. Instead, it seems logical that WC/UC funding would be financed out of general revenues.

The evidence seems to point toward most of the cost increases being incident on workers. Worrall and Durbin attest to "research evidence that, as workers' compensation costs increase for employers, employees bear much of

the cost burden through a wage tradeoff" (p. 595). In the case of WC, the vast differences in risks of occupational injuries across types of jobs complicates the analysis considerably. Gruber and Krueger (1991) find that roughly 85% of the increase in WC benefits is picked up by lower average wages when the sample is restricted to carpenters, gas station workers, plumbers, and truck drivers. For a more diverse group of employees, that number falls to around 50%.

On the basis of these findings, therefore, it seems reasonable to assume that states and localities dip into their wage outlays in order to meet new WC/UC demands. The larger question this conclusion raises is one that's germane to the larger issue of projecting taxation. It is important whether taxes are based on real wages or real wealth if benefits and wages are linked as we have suggested.

We have been assuming in our projections that the real wage bill remains a fixed proportion of GDP, and our proxy is CPS's *earned income* variable. If companies pass on the costs of higher benefits to workers directly, then our measure of real wages is technically incorrect since the proxy is not necessarily a consistent measure of the true after-benefits wage bill. Our belief that labor's share of output remains constant is not exactly at issue here; the fixed total share of annual income still gets paid to labor, but it's in a different form when benefits rise and push down wages. Call that fixed share "total compensation." We neglect for the moment income from capital, since taxes collected on that income would be the same regardless of how wages grow in relation to total compensation. Real wages would be growing somewhat slower than productivity if benefits were growing somewhat faster. This subtle distinction can create problems if some categories of taxation are based on real wages rather than real total compensation, because while total compensation can be considered growing at the rate of productivity growth, wages would actually lag behind if benefits are increasing.

For example, Gruber and Kruger point out that WC benefits are not subject to federal income tax (p. 127). While WC is a relatively small portion of wealth and will have a negligible effect, if other, larger social insurance benefits are also omitted — if taxation is more wage-based rather than labor-wealth-based — problems can arise in assuming taxes grow with the rate of productivity growth.

These effects are likely to be small. They could conceivably distort the true paths and aggregate composition of taxes, however.

If employers could pass on all of the benefit incidence, however, why would

they be motivated to arrest the movement in their experience rating? Firms that could merely lower current wages to offset the increase in expected flows of benefits would be indifferent to their experience rating. If 15% of benefit increases are in fact borne by employers, however, there may be enough of an incentive to minimize risks and keep favorable ratings.

I   State and Local Retirement

Accounting appropriately for the fiscal burden of maintaining state and local retirement programs is vital because of the sheer magnitudes involved. Assets and projected liabilities of the aggregate system are both in the neighborhood of a trillion dollars. The difficulties inherent in describing dynamics of the composite state and local retirement system are the same as those that complicate analysis of UI and Workers' Comp: Given a multitude of distinct plans among the fifty states, it's hard to make generalizations; and the true relationship between the funding of general government services and the funding of trusts is not entirely clear.

Still, there seems to be substantial evidence that state and local retirement plans are the most fully funded trusts in the state and local sector. While the retirement systems may not be completely separated from general sector finances in reality, the assumption that they are appears to be a reasonable approximation.

In 1995, the *EBRI Databook* reported that the average funding ratio among state and local public retirement systems was 85% in 1992 (Silverman p. 202). That is, for every dollar of pension benefit obligation (PBO), the average state and local plan had eighty-five cents held in trust in that year. EBRI also notes that contributions to retirement funds have outstripped benefit payments in recent years, also pointing to a more fully funded nature. One worrisome note, however, is that benefit streams have been increasing at a faster rate than contributions; the wedge between the two actually declined in nominal terms between 1985 and 1991 (Ibid, p. 176).

Mitchell and Carr (1996) report that data from 1993, comprising about 75% of the total state and local retirement sector, indicate that the ratio of assets to PBOs in the average system was a much higher 95% in that year, and the median plan was 97% funded (p. 1213–15). The aggregate number they report for all plans in the sample is 91%. It should also be noted that the number of plans reporting in the Zorn study upon which Mitchell and

Carr draw was 449, up from 340 from the study of funds in 1992 conducted by EBRI.

One of the main reasons these plans are now literally fully funded may be the diversification of the asset portfolios. Only about half the investments in 1992 were locked in relatively low-yield instruments such as various types of bonds, according to Mitchell and Carr (p. 1217). With the recent surge in stock prices during the middle 90s, the net position of the funds has likely improved.

It seems a logical choice to assume for the purposes of projections that state and local retirement systems will remain fully funded. The question becomes whether we expect there to be increases in contribution requirements that are severe enough to reevaluate how we model public sector total compensation.

Currently, as in the case of Workers' Comp, we assume that total compensation of public employees remains a congestible good driven only by the total size of the economy and specifically not by demographic pressures. Thus wages and benefits for public employees together maintain a constant share of GDP through time. Further, we tend to believe that given the evidence in the case of Workers' Comp, increases in costs of benefits tend to be transferred through to employees in the form of lower wages. Total compensation stays constant. But if the growth in benefits should be explosive, how can drops in public sector wages be equally explosive in the opposite direction?

The projected growth in benefits and therefore contributions may not be as volatile as in the cases of Social Security or medical insurance, however. Mitchell and Carr report that about a quarter of state and local retirement benefit plans are fully indexed to the CPI, and that otherwise a plan's trustees must vote to raise benefit payments (p. 1211). It is probably a reasonable assumption that contributions won't dwarf the wage bill paid to public employees, since benefit increases will probably not be as volatile or uncontrollable as those in comparable federal programs. Still, it would be useful to examine the pressures on benefit increases through time and to think about how that might change the total compensation bill that state and local governments must fund.

State and local public retirement systems are considered fully funded.

J Accounting Conventions

The federal government adheres to the following convention on total *gross* government debt:

$$G_{t+1} = (1 + r^G_{t+1})G_t + (1 + r^b_{t+1}/2)g_{t+1}, \tag{15}$$

where G is total debt issued by the government (hence "gross"), r^G is the effective real interest rate on maturing government debt, r^b is the current period's real interest rate, and g is the "primary deficit". Note that the primary deficit accrues half the year's interest. Define deficits and debts to be positive.

What exactly is g? The unified federal budget concept treats all federal programs as equally contributing to the annual deficit. That method distorts the analysis when units of the government, namely the Social Security Administration, hold claims on the Treasury, however. Since (15) does not distinguish between the identity of the owner of government debt, g must be the primary deficit *excluding* OASDI outflows and receipts. Just as similarly, g cannot include current operations of mutual funds that hold government bills.

Social Security obeys the following accounting convention:

$$bal_{t+1} = (1 + r^b_{t+1})bal_t + (1 + r^b_{t+1}/2)[INC_{t+1} - OUT_{t+1}], \tag{16}$$

where $bal > 0$ is the balance on the Trust Fund, OUT are current outlays, and INC is current income. Thus the current surplus accrues interest and is added to the Trust Fund balance, along with interest earned on the previous balance. Note that the Trust Fund (arbitrarily) accrues interest at the same rate as the periodic interest rate, r^b, to be consistent with our method of projection. If only the public and the Social Security Administration hold government debt, then:

$$G_t \equiv D_t + bal_t, \forall t \tag{17}$$

where D is the *net* debt, or total debt held by the public. Since interest payable on gross debt is separable between interest paid to the public and to the Trust Fund,

$$r^G_{t+1}G_t = r^D_{t+1}D_t + r^b_{t+1}bal_t, \tag{18}$$

where r^D, the effective rate of interest on debt held by the public is some different rate that must satisfy (18). Adding (17) and (18) yields:

$$(1 + r^G_{t+1})G_t = (1 + r^D_{t+1})D_t + (1 + r^b_{t+1})bal_t. \tag{19}$$

Since the Trust Fund holds federal debt, part of G is absorbed by bal. The primary deficit g must be by definition the excess of expenditures over taxes, not including Social Security, because the OASDI balance is already accounted for in (16). Rewriting (15) in terms of bal and D, using (17) on the left-hand side and (19) on the right, yields:

$$
\begin{aligned}
D_{t+1} + bal_{t+1} = \ & (1 + r^D_{t+1})D_t + (1 + r^b_{t+1})bal_t \\
& + (1 + r^b_{t+1}/2)[\mathcal{E}_{t+1} - \mathcal{I}_{t+1}],
\end{aligned}
\tag{20}
$$

where $\mathcal{E}$ and $\mathcal{I}$ are expenditures and income across the rest of the federal government; $\mathcal{E} - \mathcal{I} \equiv g$. Combining (20) with (16) could produce a formula for D_{t+1} in terms of D_t, interest rates, and total current operations (eliminating bal altogether) if desired.

To make this more intuitive, one can derive (20) using a different route, beginning with the definition of the unified budget deficit as the change in the debt held by the public. Using the same notation, we have:

$$
D_{t+1} = (1 + r^D_{t+1})D_t + (1 + r^b_{t+1}/2)d_{t+1},
\tag{21}
$$

where d is the unified primary budget deficit. Making sure we keep the signs right, we split d up into its components:

$$
\begin{aligned}
D_{t+1} = \ & (1 + r^D_{t+1})D_t + (1 + r^b_{t+1}/2)g_{t+1} \\
& + (1 + r^b_{t+1}/2)[OUT_{t+1} - INC_{t+1}],
\end{aligned}
\tag{22}
$$

where as before, g is the non-OASDI primary deficit (i.e., $g > 0$ means there is more spending than income), and OASDI inflows and outlays are switched in the order of their appearance, relative to (16), since they must show an OASDI deficit as a positive number. Rearranging (16) shows us that:

$$
(1 + r^b_{t+1}/2)[OUT_{t+1} - INC_{t+1}] = (1 + r^b_{t+1})bal_t - bal_{t+1},
\tag{23}
$$

so substituting (23) into (22) yields:

$$
\begin{aligned}
D_{t+1} &= (1 + r^D_{t+1})D_t + (1 + r^b_{t+1}/2)g_{t+1} + (1 + r^b_{t+1})bal_t - bal_{t+1}, \\
D_{t+1} + bal_{t+1} &= (1 + r^D_{t+1})D_t + (1 + r^b_{t+1})bal_t + (1 + r^b_{t+1}/2)g_{t+1},
\end{aligned}
\tag{24}
$$

which is identical to (20).

Total annual interest payments, in a unified budget sense, are given by the far-right component of the following reordered version of (21):

$$
D_{t+1} = D_t + d_{t+1} + [r^D_{t+1}D_t + (r^b_{t+1}/2)d_{t+1}].
\tag{25}
$$

K   Balancing algorithms

K.1   Federal taxes for a given D/Y

The basic difference equation relating current $(t + 1)$ debt to last year's debt, current and last year's Trust Fund balance, interest rates, and current primary deficit, is:

$$D_{t+1} + bal_{t+1} = (1 + r_{t+1}^D)D_t + (1 + r_{t+1}^b)bal_t + (1 + r_{t+1}^b/2)[\mathcal{E}_{t+1} - \mathcal{I}_{t+1}]. \quad (26)$$

Altering (26) to account for a tax hike of τ applied evenly to all categories of taxation yields:

$$D_{t+1} + bal_{t+1} = (1 + r_{t+1}^D)D_t + (1 + r_{t+1}^b)bal_t + (1 + r_{t+1}^b/2)[\mathcal{E}_{t+1} - (1 + \tau)\mathcal{I}_{t+1}]. \quad (27)$$

If we stipulate a constant τ through time, and taking the Trust Fund balance, interest rates, and the current primary deficit as given, we can transform (27) into an equation that expresses τ as a function of known variables and two levels of debt. So for any current level of debt D_0, a particular debt target D_T that is T years in the future will determine a constant tax hike τ to be applied in every intervening year to reach D_T. For now we set $T = 5$, but these results could easily be generalized to other T.

For example, advancing (27) yields:

$$\begin{aligned} D_{t+5} = \quad & -bal_{t+5} + (1 + r_{t+5}^D)D_{t+4} + (1 + r_{t+5}^b)bal_{t+4} \\ & +(1 + r_{t+5}^b/2)[\mathcal{E}_{t+5} - (1 + \tau)\mathcal{I}_{t+5}], \end{aligned} \quad (28)$$

and we also know that D_{t+4} is given by:

$$\begin{aligned} D_{t+4} = \quad & -bal_{t+4} + (1 + r_{t+4}^D)D_{t+3} + (1 + r_{t+4}^b)bal_{t+3} \\ & +(1 + r_{t+4}^b/2)[\mathcal{E}_{t+4} - (1 + \tau)\mathcal{I}_{t+4}]. \end{aligned} \quad (29)$$

We premultiply (29) by $R_{t+5}^D \equiv (1 + r_{t+5}^D)$ to obtain:

$$\begin{aligned} R_{t+5}^D D_{t+4} = \quad & -R_{t+5}^D bal_{t+4} + R_{t+5}^D R_{t+4}^b bal_{t+3} + R_{t+5}^D R_{t+4}^D D_{t+3} \\ & +R_{t+5}^D R_{t+4}^{hb}[\mathcal{E}_{t+4} - (1 + \tau)\mathcal{I}_{t+4}], \end{aligned} \quad (30)$$

where $R_{t+4}^{hb} \equiv (1 + r_{t+4}^b/2)$. Notice the change in the order of terms; we keep all Trust Fund balance terms on the left next to the equals sign, the Debt

in the middle, and the current primary deficit on the right. Using the new notation, (28) becomes:

$$
\begin{aligned}
D_{t+5} = \; & -bal_{t+5} + R^b_{t+5}bal_{t+4} + R^D_{t+5}D_{t+4} \\
& +R^{hb}_{t+5}[\mathcal{E}_{t+5} - (1+\tau)\mathcal{I}_{t+5}],
\end{aligned}
\tag{31}
$$

Substituting (30) into (31), we arrive at:

$$
\begin{aligned}
D_{t+5} = \; & -bal_{t+5} + R^b_{t+5}bal_{t+4} - R^D_{t+5}bal_{t+4} + R^D_{t+5}R^b_{t+4}bal_{t+3} \\
& +R^D_{t+5}R^D_{t+4}D_{t+3} + R^D_{t+5}R^{hb}_{t+4}[\mathcal{E}_{t+4} - (1+\tau)\mathcal{I}_{t+4}] \\
& +R^{hb}_{t+5}[\mathcal{E}_{t+5} - (1+\tau)\mathcal{I}_{t+5}].
\end{aligned}
\tag{32}
$$

We know that $R^D_{t+5}R^D_{t+4}D_{t+3}$ is given by a derivant of (30):

$$
\begin{aligned}
R^D_{t+5}R^D_{t+4}D_{t+3} = \; & -R^D_{t+5}R^D_{t+4}bal_{t+3} + R^D_{t+5}R^D_{t+4}R^b_{t+3}bal_{t+2} + R^D_{t+5}R^D_{t+4}R^D_{t+3}D_{t+2} \\
& +R^D_{t+5}R^D_{t+4}R^{hb}_{t+3}[\mathcal{E}_{t+3} - (1+\tau)\mathcal{I}_{t+3}],
\end{aligned}
\tag{33}
$$

so we summarily rewrite (32) as:

$$
\begin{aligned}
D_{t+5} = \; & -bal_{t+5} + R^b_{t+5}bal_{t+4} - R^D_{t+5}bal_{t+4} + R^D_{t+5}R^b_{t+4}bal_{t+3} \\
& -R^D_{t+5}R^D_{t+4}bal_{t+3} + R^D_{t+5}R^D_{t+4}R^b_{t+3}bal_{t+2} + R^D_{t+5}R^D_{t+4}R^D_{t+3}D_{t+2} \\
& +R^D_{t+5}R^D_{t+4}R^{hb}_{t+3}[\mathcal{E}_{t+3} - (1+\tau)\mathcal{I}_{t+3}] \\
& +R^D_{t+5}R^{hb}_{t+4}[\mathcal{E}_{t+4} - (1+\tau)\mathcal{I}_{t+4}] \\
& +R^{hb}_{t+5}[\mathcal{E}_{t+5} - (1+\tau)\mathcal{I}_{t+5}].
\end{aligned}
\tag{34}
$$

The pattern is clearly emerging. Including two more steps, we would arrive at the following expression for D_{t+5} in terms of the interest rates, the stream of Trust Fund balances, the stream of primary deficits (including the tax rate), and current debt D_t. Note here that because the Trust Fund balance accumulates interest at a different rate than the net federal Debt (i.e., debt held by the *public* rather than Social Security), each year's Trust Fund balance enters the equation twice rather than cancelling out altogether.

$$
\begin{aligned}
D_{t+5} = \; & -bal_{t+5} + R^b_{t+5}bal_{t+4} - R^D_{t+5}bal_{t+4} + R^D_{t+5}R^b_{t+4}bal_{t+3} \\
& -R^D_{t+5}R^D_{t+4}bal_{t+3} + R^D_{t+5}R^D_{t+4}R^b_{t+3}bal_{t+2} - R^D_{t+5}R^D_{t+4}R^D_{t+3}bal_{t+2} \\
& +R^D_{t+5}R^D_{t+4}R^D_{t+3}R^b_{t+2}bal_{t+1} - R^D_{t+5}R^D_{t+4}R^D_{t+3}R^D_{t+2}bal_{t+1} \\
& +R^D_{t+5}R^D_{t+4}R^D_{t+3}R^D_{t+2}R^b_{t+1}bal_t + R^D_{t+5}R^D_{t+4}R^D_{t+3}R^D_{t+2}R^D_{t+1}D_t
\end{aligned}
$$

$$+R^D_{t+5}R^D_{t+4}R^D_{t+3}R^D_{t+2}R^{hb}_{t+1}[\mathcal{E}_{t+1} - (1+\tau)\mathcal{I}_{t+1}]$$
$$+R^D_{t+5}R^D_{t+4}R^D_{t+3}R^{hb}_{t+2}[\mathcal{E}_{t+2} - (1+\tau)\mathcal{I}_{t+2}]$$
$$+R^D_{t+5}R^D_{t+4}R^{hb}_{t+3}[\mathcal{E}_{t+3} - (1+\tau)\mathcal{I}_{t+3}]$$
$$+R^D_{t+5}R^{hb}_{t+4}[\mathcal{E}_{t+4} - (1+\tau)\mathcal{I}_{t+4}]$$
$$+R^{hb}_{t+5}[\mathcal{E}_{t+5} - (1+\tau)\mathcal{I}_{t+5}]. \tag{35}$$

Solving (35) for τ, we wind up with:

$$
\begin{aligned}
\tau = \ \frac{1}{C}[&-D_{t+5} - bal_{t+5} + R^b_{t+5}bal_{t+4} - R^D_{t+5}bal_{t+4} + R^D_{t+5}R^b_{t+4}bal_{t+3} \\
&-R^D_{t+5}R^D_{t+4}bal_{t+3} + R^D_{t+5}R^D_{t+4}R^b_{t+3}bal_{t+2} - R^D_{t+5}R^D_{t+4}R^D_{t+3}bal_{t+2} \\
&+R^D_{t+5}R^D_{t+4}R^D_{t+3}R^b_{t+2}bal_{t+1} - R^D_{t+5}R^D_{t+4}R^D_{t+3}R^D_{t+2}bal_{t+1} \\
&+R^D_{t+5}R^D_{t+4}R^D_{t+3}R^D_{t+2}R^b_{t+1}bal_t + R^D_{t+5}R^D_{t+4}R^D_{t+3}R^D_{t+2}R^D_{t+1}D_t \\
&+R^D_{t+5}R^D_{t+4}R^D_{t+3}R^D_{t+2}R^{hb}_{t+1}\mathcal{E}_{t+1} + R^D_{t+5}R^D_{t+4}R^D_{t+3}R^{hb}_{t+2}\mathcal{E}_{t+2} \\
&+R^D_{t+5}R^D_{t+4}R^{hb}_{t+3}\mathcal{E}_{t+3} + R^D_{t+5}R^{hb}_{t+4}\mathcal{E}_{t+4} + R^{hb}_{t+5}\mathcal{E}_{t+5}] - 1, \tag{36}
\end{aligned}
$$

where C is given by:

$$
\begin{aligned}
C = \ &R^D_{t+5}R^D_{t+4}R^D_{t+3}R^D_{t+2}R^{hb}_{t+1}\mathcal{I}_{t+1} + R^D_{t+5}R^D_{t+4}R^D_{t+3}R^{hb}_{t+2}\mathcal{I}_{t+2} \\
&+R^D_{t+5}R^D_{t+4}R^{hb}_{t+3}\mathcal{I}_{t+3} + R^D_{t+5}R^{hb}_{t+4}\mathcal{I}_{t+4} + R^{hb}_{t+5}\mathcal{I}_{t+5}. \tag{37}
\end{aligned}
$$

K.2 State and Local taxes

To find state and local taxes that target a given net debt to GDP level in five years, we use the same algorithm as described above in (36) and (37), except the Trust Fund balances are all zero.

K.3 Finding OASDI payroll taxes, given *bal*

Following the structure of the previous section, the OASDI system can achieve internal balance through a similar perfect-foresight, limited-horizon algorithm that targets a particular level of the Trust Fund balance, *bal*. Our balancing mechanism, aiming for a Trust Fund ratio (defined as the current balance over the next year's total outlays) of 2.5, looks five years into the future with perfect foresight and sets a single tax rate on payroll taxes so as to bring the Trust Fund ratio exactly to 2.5 in five years.

The year in which this mechanism first kicks in depends on the total time-path that the Trust Fund ratio would otherwise take in the absence of balancing. With perfect foresight, the budget authority chooses either:

- five years before the year of the maximum ratio — or the tenth year, whichever is smaller — if the ratio never exceeds 2.5; or

- five years before the ratio is to hit 2.5 the last time, if the ratio ends the 75-year projection above 2.5; or

- five years before the ratio is to hit 2.5 the last time

In general, the various trajectories of the Trust Fund Ratio correspond to the three general shapes found in the OASDI Trustees' Report; either the ratio never reaches and peaks below 2.5 (high-cost estimate), the ratio exceeds and stays above 2.5 (low-cost estimate), or the ratio crosses 2.5 twice. Notice the second and third rules are mechanically identical; working backward from the end of the projection, the OASDI system balances around the latest crossing point, thus preserving any "humps" the trajectories might have that characterize times of high surplus.

Once tripped, this 5-year forward-looking algorithm operates every single year henceforth.

The single tax rate that is calculated for every five-year outlook is given by a formula very similar to (36). The basic accounting identity is (16), but with a slight enhancement. Since INC is composed of payroll taxes and taxes on benefits, we rewrite the fundamental difference equation as:

$$bal_{t+1} = (1 + r^b_{t+1})bal_t + (1 + r^b_{t+1}/2)[X_{t+1} + b_{t+1} \cdot B_{t+1} - OUT_{t+1}], \quad (38)$$

where X represents payroll taxes, and $b \cdot B$ is the product of a composite benefit tax rate and benefit totals. Then the tax rate τ is given by:

$$\tau = -\frac{K}{C} - 1, \quad (39)$$

where

$$\begin{aligned} K = \ & R_{t+5}R_{t+4}R_{t+3}R_{t+2}R^h_{t+1}(b_{t+1} \cdot B_{t+1} - OUT_{t+1}) \\ & + R_{t+5}R_{t+4}R_{t+3}R^h_{t+2}(b_{t+2} \cdot B_{t+2} - OUT_{t+2}) \\ & + R_{t+5}R_{t+4}R^h_{t+3}(b_{t+3} \cdot B_{t+3} - OUT_{t+3}) \\ & + R_{t+5}R^h_{t+4}(b_{t+4} \cdot B_{t+4} - OUT_{t+4}) \\ & + R^h_{t+5}(b_{t+5} \cdot B_{t+5} - OUT_{t+5}) \\ & + R_{t+5}R_{t+4}R_{t+3}R_{t+2}R_{t+1}bal_t - bal_{t+5}, \quad (40) \end{aligned}$$

and

$$C = \quad R_{t+5}R_{t+4}R_{t+3}R_{t+2}R_{t+1}^h X_{t+1}$$
$$+R_{t+5}R_{t+4}R_{t+3}R_{t+2}^h X_{t+2}$$
$$+R_{t+5}R_{t+4}R_{t+3}^h X_{t+3}$$
$$+R_{t+5}R_{t+4}^h X_{t+4} + R_{t+5}^h X_{t+5}. \qquad (41)$$

Following the previous convention, R refers to one plus the OASDI interest rate, the single effective rate that we assume applies to balance and principal. R^h is one plus one-half that rate.

L Medicare

Estimating the growth of Medicare is a complicated task due to the connections between medical care costs by age and longevity. Recent work by Tim Miller (1998) has demonstrated the potential for severe overstatements in mainstream projections of Medicare, notably by HCFA itself. Projections based on age profiles of usage rates or incurred expenses will exaggerate annual medical costs, because such forecasts are based on the flawed assumption that Americans of a given age in the future will require treatment at the same rate they do today.

When people live longer, not only are there more Americans of a certain age, an effect that age profiles *do* pick up; they are more healthy at those older ages than their earlier counterparts ever were. Costs of caring for the healthy aged are considerably lower than the costs of caring for the sick or terminally ill. For example, current estimates place the average Medicare costs of dying patients at five times the average costs of patients who live at least another year. When mortality is falling, a large share of Medicare obligations are redistributed toward the future; people simply are sick and die later.

Ignoring the finer points concerning Miller's concept of thanatological age (time until death) in conjunction with chronological age and the healthiness of the aged, we model this "delaying effect" as providing the backbone for our projections of Medicare. We define three groups of Americans over 65 (prospective Medicare patients) in each year: the dying, who die within the year; the morbid, who die one to three years from the current period; and the rest of the population. We assume that regardless of age, the morbid

cost on average 2.77 times as much as the rest of the over-65 population, and the dying cost 7.41 times as much. There is no distinction made on the basis of age. In a sense, our method simulates a creeping age profile that shifts according to mortality decline.

This analysis does not differentiate between sudden and protracted deaths, assuming instead that they will remain in roughly the same proportion through time. This aspect may be crucial since HI outlays for a population of auto-accident victims would surely be lower than for a population of nursing home residents, but such a level of distinction is beyond the scope of this paper. In applying an average cost to the entire residual population over 65, we are assuming that the costs of providing Medicare to the non-dying, non-morbid population as a share of the total eligible (non-dying, non-morbid) population remains constant. Additionally, we're assuming that costs can be averaged in the same way over morbid and dying subpopulations eligible for Medicare. Were patterns of Medicare usage conditional on health status to change, our results would suffer accordingly.

It turns out that using static age profiles of Medicare enrollment does not significantly change the results from the method outlined above. Since enrollment rates are virtually constant across ages above 65, age profiles of enrollment treat everyone over 65 as being roughly the same, sort of a first-order approximation to the distinction by time of death. On the other hand, official projections by HCFA emphasize costs by age, which tend to be increasing in age. As the population ages, larger cohorts at older ages, who realistically will be getting sick less and leading healthier lives, push HCFA projections above those using the enrollment method. Using enrollment rates is therefore a step in the right direction, at least. Focusing on mortality and morbidity gives a more accurate picture of the long-run pressures, however.

M Medicaid

Generally speaking, while Medicaid serves a role similar to Medicare in its provision of medical care, the target populations are vastly different. Medicaid funds facility care for elderly populations who are institutionalized in nursing homes or in home care arrangements. These same subpopulations also absorb Medicare when hospital care is needed. Medicaid also targets low-income Americans; a cross-sectional age profile shows high rates of enrollment at young ages which represent children in poverty; see figure 9.

Without much loss of generality, we can split Medicaid into two portions: institutionalized and noninstitutionalized. The latter group receives Medicaid because they are poor; the former because they are sick.

Granted, there is a large degree of overlap between being poor and being sick, as evidenced by the fact that many institutionalized elderly are also poor. The presence of "spend-down" effects, in which the sick qualify for Medicaid by divesting themselves of assets, would bias any analysis that relied on independence between medical condition and wealth. Still, it seems plausible that institutionalization is a function of health alone; poor people aren't institutionalized simply because they're poor. So while health in turn may be a function of wealth, it is fair to say that institutionalization depends only on health status. Whether nursing home residents are poor or not is assumed to be irrelevant.

Since health is very likely a function of wealth, we imagine the noninstitutionalized Medicaid recipients as consisting of people who are sick because they are poor. Their Medicaid use rises according to an age profile that is fixed through time, because it is tied to poverty status.

Thus Medicaid expenditures in any year are the sum of payments to the noninstitutionalized, whose needs increase with the age profile of enrollment and productivity, and payments to the institutionalized, whose pattern of benefit growth is explained later.

M.1   Caveats

A conceptual problem with this approach arises because under these assumptions, it follows that poor noninstitutionalized people today should be more likely to become institutionalized tomorrow because health status is a serially correlated characteristic. In our model, we choose to assume that there is no connection between the amount of people who are poor (and on Medicaid) in one year and the amount of institutionalized in future years. Given that implicit poverty rates by age are being held constant, we think this is a reasonable assumption.

Another simplifying assumption is to focus on institutionalization as consisting of the elderly alone, defined as all people over the age of 65. While there exist terminally ill young patients in institutional care, they are not a significant share of the population.

A third point to be made concerns the growing use in recent history of home care, which is most likely a substitute for nursing home care. We elect

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Figure 9: Medicaid Enrollment Rates

Noninstitutionalized Medicaid Enrollment Rate Age Profile, F and M(−−)
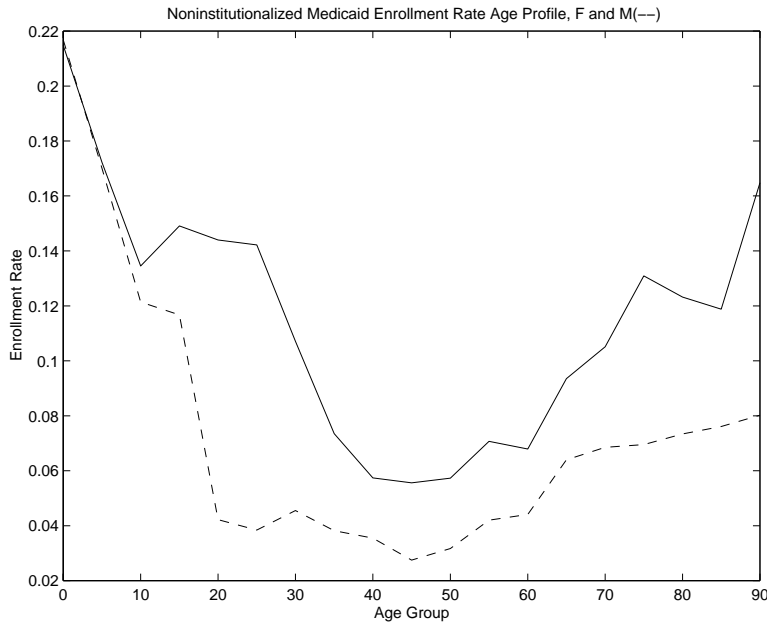
to ignore the special characteristics of people in home care. One reason is that there are measurement problems: they aren't measured by nursing home data, and it's unclear whether they are included in household data collected in the CPS. Conceivably, if home care is growing in its use as an alternative to nursing home care, our predictions concerning institutionalized populations may be called into question.

M.2   Noninstitutionalized

Figure 9 shows medicaid enrollment rates by age, based on CPS data from 1992 to 1996. The Current Population Survey doesn't include people in nursing homes, so we assume that the entire derived age profile is representative of the noninstitutionalized Medicaid population. Since this group absorbs Medicaid mostly due to reasons of poverty rather than health status (again, a simplification), we assume that the age profile of usage remains constant through time, just as a fixed share of each age group is projected to remain impoverished.

M.3 Institutionalized

To project the institutionalized component, data on current residents of nursing homes from the 1977, 1985, and 1995 rounds of the National Nursing Home Survey (NNHS), conducted by the National Center for Health Statistics (NCHS), was gathered and analyzed. Population data by single year of age was also collected from hardcopy and electronic version of the Census's P-25 reports for those years.[31]

Each round of the survey included a current resident component, which gathered data on a portion of the institutionalized population in the given year and constructed weights with which to estimate population characteristics. The total institutionalized population for each year by age group was constructed using those weights. Participation in Medicaid was measured by questions about the primary and secondary sources of funding for current residents. For our purposes, a Medicaid patient was in general anyone whose primary or secondary sources of payment either at admission or in the last month prior to interview included Medicaid. While this measure may seem overly broad, it was chosen in order to more accurately describe the resident's funding source over an entire year. Counting as a *current* Medicaid patient someone who was on Medicaid upon admission regardless of current funding status may be improper, but the preponderance of evidence suggests that Medicaid use is positively rather than negatively serially correlated. Once you're on Medicaid, you won't leave, except for a brief stay in hospital care perhaps. Expenses data were also surveyed but not used here, since the measures seem fraught with problems involving the billing period.
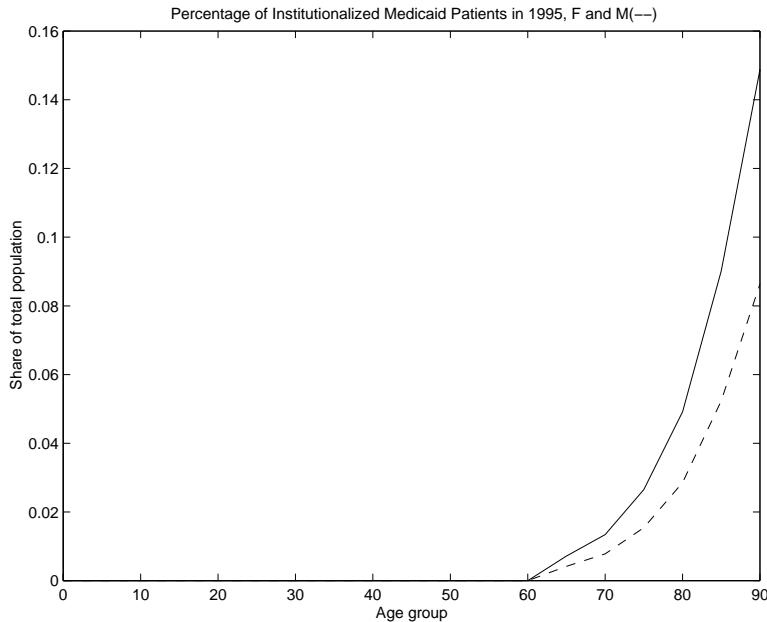
We found that the age profile of Medicaid patients who were institutionalized remained fixed in shape through time, while the entire age profile itself was declining at a rate of about 0.45% per year. Our method was regressing the log of the share of institutionalized Medicaid patients by age against single-year-of-age dummies, sex dummies, and time dummies, using the 1977, 1985, and 1995 Current Resident data from the NNHS. Interaction effects between dummies were used and were dropped due to insignificance.

To create an age profile of institutionalized Medicaid use out of the entire population, we measure by age the proportion of institutionalized Medicaid

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[31]Population totals for 1977 aggregated all age groups aged 85 years and over into a single bin. The relative age distribution from 1980 was superimposed over the 1977 data in order to recover an approximate age structure, given the total population 85 and over in 1977.

Figure 10: Institutionalized Medicaid Enrollment Rates

Percentage of Institutionalized Medicaid Patients in 1995, F and M(– –)

patients relative to the total population, all in 1995. The age profiles that result are depicted in figure 10, and these are used in the projections.

The per-head cost of providing services to institutionalized Medicaid patients is assumed to be constant through age. Since nursing home care consists of nursing and "intermediate" care, rather than medical procedures, this is probably not a gross oversimplification.

In fact, the age profile of institutionalized Medicaid usage has not been constant over time (which the above method implicitly assumes). A discussion of a possible alternative (but unused) technique to forecast institutionalized Medicaid follows.

M.4 An alternate (not used) model for institutionalized Medicaid

Since we suspect that health status determines institutionalization, it follows that some measure of health should be linked to institutionalization rates. We chose death rates to reflect underlying healthiness, obtaining age-specific rates by sex for the years in question from John Wilmoth's Berkeley Mortality

Database. Those data are based on life tables created by the Social Security Administration. Henceforth we use death rates as instruments for a truer measure of "ill health."

We constructed institutionalization rates by age and sex by dividing the age profile of nursing home residents in each of the three years by the population totals. The point-wise ratio of this institutionalization age profile over the age-specific death rates was then calculated for each year and compared. If the resulting pseudo-probability of institutionalization given rates of ill health were to form a constant age profile, we could project institutionalized populations through time given the age-specific death rates. The implicit model here is that the conditional probability of institutionalization given ill health is equal to the joint probability of ill health and institutionalization divided by the unconditional probability of ill health:

$$Pr\{I \mid ih\} = \frac{Pr\{I, ih\}}{Pr\{ih\}}, \tag{42}$$

where I represents institutionalization, and ih represents ill health. If we assume everyone who is institutionalized is in ill health ($Pr\{ih \mid I\} = 1$), then the institutionalization rate that we're actually using to compute the numerator, $Pr\{I\}$, is indeed the same as $Pr\{I, ih\}$.

Contrary to our expectations, the ratio of the unconditional probabilities *for women* was not constant through time, based upon visual examination and statistical curve-fitting. For men, the age-specific probabilities were constant through time. The method used was a simple linear regression of $Pr\{I \mid ih\}$ on age, age squared, and dummy variables for sex and time (which were interacted). Linear methods were used even though outcomes for individuals are discrete, binomial choice variables because the data was in the form of population ratios.

There could be a number of problems with (42), but the most likely is probably departures from nursing home residents being in ill health, as defined above. That is,

$$Pr\{ih \mid I\} \neq 1. \tag{43}$$

Since (42) seems to fit men reasonably well, there's either a third offsetting effect (that is, our model is completely wrong), or $Pr\{ih \mid I\} = 1$ for men. For women, (43) is a candidate.

This points to two questions, "why do people enter nursing homes, and are the reasons different for men and for women?" Chronic illness seems to

describe male patterns of nursing care relatively well; if a man is in a nursing home, he's chronically ill. For women, we suspect there has been a second effect increasing nursing home patronage, which derives from surviving by many years one's partner. It is likely that elderly women also enter nursing care not because of their own health status, but because of their husband's death. Why the asymmetry? Simply because women have greater life expectancy and tend to be younger than their spouses, women outlive them. For such nursing home residents, it is altogether probable that (43) is true.

Interestingly, controlling for Medicaid usage among the institutionalized seems to control for ill health as well, neatly eliminating the problem that (43) presents. Medicaid patients among the elderly tend to be the terminally ill, so it is intuitively reasonable to suspect that $Pr\{ih \mid I, M\} = 1$ for both sexes is a better assumption than $Pr\{ih \mid I\} = 1$. Then (42) becomes:

$$Pr\{I, M \mid ih\} = \frac{Pr\{I, M, ih\}}{Pr\{ih\}}, \qquad (44)$$

where M represents Medicaid usage. Again, our pivotal assumption in actually calculating (44) is that the numerator, $Pr\{I, M, ih\}$, simply equals $Pr\{I, M\}$; everyone who is institutionalized and on Medicaid is also in ill health.

The age profile defined by $Pr\{I, M \mid ih\}$ was found to be constant through time by means of a simple linear regression of $Pr\{I, M \mid ih\}$ on age, age squared, and dummy variables for sex and time (which were interacted). The general model was identical to the previous. Coefficients on the year and year-sex dummies were all found to be quite insignificant, indicating the lack of a time trend for either men or women. These findings lead us to believe that (44) is a good method of projecting institutionalized Medicaid patients. The cost of an institutionalized Medicaid patient will be assumed constant through all characteristics for convenience. We have no reason to suspect that the average cost of the Medicaid population in nursing homes is not representative of the distribution.

In contrast, usage of Medicaid by institutionalized populations was found to have a significant positive time trend across both sexes evenly. A discrete choice probit model was fitted to usage of Medicaid by nursing home residents over 65 using age and sex and year dummies (the relationship is linear rather than parabolic through age).[32] The findings were that being a resident in

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[32]As remarked in the literature, while logit and probit models assume different distri-

1985 had the marginal effect of raising the probability of Medicaid use by about 3.9% and being a resident in 1995 raised the probability by about 16.3%, both measures significantly different from zero at the 1% level.

These findings are not inconsistent with the view that Medicaid recipients in nursing homes are in ill health regardless of sex; that is, $Pr\{ih \mid I, M\} = 1$. What is happening is that the resident structure of nursing homes is clearly changing through time. Women's institutionalization rates are not well explained by their ill health (death rates); a second subpopulation of the institutionalized, that of elderly women who aren't on Medicaid and who apparently are not in ill health, is changing its usage of nursing homes. The reason may be related to their wealth. An improvement in incomes of elderly women brought about by Social Security has been shown to cause changes in living arrangements by McGarry and Schoeni (1998), so the unexplained decline in institutionalization rates among women may be related. Since such an argument is unnecessary here — we are not interested in projecting the non-Medicaid institutionalized population — and since it is potentially problematic, dealing with the complicated interaction between wealth levels and health status, we do not confront the issue here.

M.5   Control totals

According to HCFA,[33] in 1994 \$137.6bn was allocated as total program payments (\$78.6bn was the federal share), of which \$108.3bn represented vendor payments (payments directly to providers). Additionally, administrative payments totalled \$6.2bn, of which \$3.1bn was paid by the federal government.[34] Of the almost \$30bn excess in total payments over vendor payments, apparently a little more than half went toward payments for premiums, and the other half was directed toward disproportionate share hospitals.[35]

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butions, there tends to be relatively little difference in model results between them. Such was the case with Medicaid usage rates among current residents. A probit model was used to find marginal effects because *Stata* has convenient built-in functions for doing so; the logit model's results could only be easily transformed into odds-ratios.

[33] *Medicaid National Summary Statistics* Table 1: Medicaid Recipients, Vendor, Medical Assistance and Administrative Payments, gleaned from HCFA-2082 reports; www.hcfa.gov/medicaid/2082-1.htm

[34] "Total payments" apparently does not include administrative payments; see Mary Onnis Waid, "Brief Summaries of Medicare & Medicaid," at

www.hcfa.gov/medicare/ormedmed.htm

[35] ibid.

Of the vendor payments, 25% went to nursing facility services of the kind we are considering here.[36] While it's difficult to know the direction of the remaining $30bn of funding, it seems like a fair assumption that 25% is heading toward institutionalized care as well. Additionally, we shall assume that federal and state funds are split across both types of Medicaid as designated here according to their shares in the total program funding.

Thus in 1994, the federal share of Medicaid was $19.7bn for the institutionalized portion, $58.9bn for the noninstitutionalized portion, and $3.1bn in administrative payments. The state and local share was split up as $14.8bn, $44.2bn and $3.1bn. *Currently, the control totals at the state and local level are set at $15.4bn and $62.1bn for institutionalized and noninstitutionalized.*

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Table 2: Growth Stimuli in Pct Points

Year	Med Care
1994	0.0472
1995	0.0472
1996	0.0430
1997	0.0388
1998	0.0346
1999	0.0304
2000	0.0262
2001	0.0230
2002	0.0198
2003	0.0166
2004	0.0134
2005	0.0102
2006	0.0088
2007	0.0074
2008	0.0060
2009	0.0046
2010	0.0032
2011	0.0028
2012	0.0024
2013	0.0020
2014	0.0016
2015	0.0012
2016	0.0012
2017	0.0012
2018	0.0012
2019	0.0012
2020	0.0012

Table 3: State Prison Inmates in 1986 and 1991

	1986	%	1991	%
Total	450,416		711,643	
under 18	2,507	0.46	4,552	0.64
18–24	120,384	26.73	151,328	21.26
25–34	205,817	45.69	325,429	45.73
35–44	87,502	19.43	161,651	22.72
45–54	23,524	5.22	46,475	6.53
55–64	8,267	1.84	16,997	2.39
65+	2,808	0.62	5,210	0.73

Table 4: State Prison Incarceration Rates

	1986	1991	Δ	Factor
Total	0.19	0.28	0.09	0.50×
under 18	0.01	0.03	0.02	1.42×
18–24	0.30	0.42	0.11	0.37×
25–34	0.49	0.76	0.27	0.56×
35–44	0.27	0.41	0.15	0.55×
45–54	0.10	0.18	0.08	0.74×
55–64	0.04	0.08	0.04	1.15×
65+	0.01	0.02	0.01	0.69×

Table 5: Real State Expenditures on Corrections

Year	Growth (%)	per GDP (%)
1983	10.06	0.28
1984	8.65	0.29
1985	10.71	0.31
1986	12.84	0.34
1987	7.46	0.35
1988	10.43	0.38
1989	6.46	0.39
1990	10.24	0.43
1991	6.84	0.46
1992	3.30	0.47

Table 6: Nominal State Expenditures on Corrections

Year	Nominal ($m)	Growth (%)
1982	8,536	
1983	9,835	14.2
1984	11,147	12.5
1985	12,815	14.0
1986	14,961	15.5
1987	16,625	10.5
1988	19,131	14.0
1989	21,264	10.6
1990	24,560	14.4
1991	27,356	10.8
1992	29,050	6.0

Table 7: Census Bureau Corrections

Year	Corr ($bn)	GDP ($bn)	ratio (%)
1992	28.7	6220.9	0.45
1993	29.6	6560.5	0.44
1994	32.3	6947.8	0.46
1995	35.9	7322.2	0.49
1996	37.5	7699.1	0.49