Economics 203 Matthias Doepke
Macroeconomics II Spring 2000

Problem Set 4

Some questions on this problem set require the use of a spreadsheet program (like Excel). Therefore you can do questions 1 to 2 in groups of up to three people, and you need to hand in only one answer for the group. Questions 3 and 4 are to be done individually.

The Future of Social Security

In the following questions you will simulate the future of Social Security. Social Security is a government program that taxes current workers to pay for the retirement benefits of current retirees. Since the large baby-boomer cohorts are going to retire within the next twenty to thirty years and only relatively few workers will be left to pay for retirement benefits, social security taxes are projected to increase significantly in the future. In the following problems, you will compute the future time path of social security under different demographic, political, and economic assumptions.

The simulation is done in three parts. First, you need to forecast the future population by age group. This is done by using current population figures together with assumptions on birth rates and life expectancy. Next, you need to compute the total amount of wages paid in the economy. This is done by making assumptions on average future wage growth and the beginning and end of working life. Finally, the total value of retirement benefits needs to be computed. This can be be computed from assumptions on the retirement age, life expectancy, and the level of benefits relative to wages.

The only actual data that you will need is the current U.S. population by age group (in five-year intervals). This data is available from the U.S. Census Bureau, online at `http://www.census.gov/`. There is a link from the course home page. From the home page of the Census Bureau, click on "People - Estimates," "Population Estimates - National,""Annual Population Estimates by Age Group and Sex," and "Population Data." You will need the most recent (March 2000) estimates for both sexes by age group (0-4 years, 5-9 years, up to 95-99 years).

Below, I will give you step-by-step instructions how to do this analysis in Excel. Of course, you are free to use any other software, and even within the same software there are different ways of reaching the same result. If you have experience, feel free to approach this problem in your preferred way. Otherwise, stick with me.

The first task is enter our assumptions on various variables into the spreadsheet. In Figure 1 you can see the top-left corner of my spreadsheet. I first entered the assumed growth rate for wages, in my sheet into cell `D4`. The main part of the spreadsheet starts right below. The first column contains only text, columns `B` and `C` contain the lowest and highest ages for the five-year age groups I am using (0 to 4, 5 to 9, all the way up to 95-99 in row 32. Columns `D` to `X` correspond to the years 2000 to 2100, in five-year steps. In the first row I entered wages in each year. Since the absolute level does not matter, I normalized the wage in 2000 to 1, so I entered `1` in cell `D7` (row 7 contains wages in my spreadsheet). The wage in 2005 is computed given the growth rate of wages in cell `D4`, i.e., the formula for cell `E7` is `=(1+$D$4)^5*D7`. The dollar signs ensure that the reference to cell `D4` is not shifted as I copy the formula to other cells. The growth rate is taken to the power of 5 since we work with five-year intervals. Now the wages for the other years can be computed by copying the cell `E7` to the cells `F7` to `X7`. For example, the resulting formula in `F7` is `=(1+$D$4)^5*E7`. After you are done with this, you can change the growth rate in `D4` and see directly how that will affect wages over the next 100 years.

The next row contains the benefit ratio, i.e., retirement benefits as a fraction of the last wage for the generation that is currently retiring. There is no formula for this, you need to enter the data directly. I took 0.7 to be the baseline case. The next row (row 9 on my sheet) is life expectancy. Again, you have to enter the data directly, and I took 80 as the baseline case. Currently, actual life expectancy is slightly lower, but since some people die before reaching retirement age, we have to adjust the number upward to catch the

The Future of Social Security

Wage growth per year:			0.015						
Year			2000	2005	2010	2015	2020	2025	2030
Wage:			1	1.077284	1.160541	1.250232	1.346855	1.450945	1.56308
Benefit Ratio:			0.7	0.7	0.7	0.7	0.7	0.7	0.7
Life Expectancy:			80	80	80	80	80	80	80
Total Fertility Rate:			2	2	2	2	2	2	2
Start of Working Life:			25	25	25	25	25	25	25
Retirement Age:			65	65	65	65	65	65	65
Population:	0	4							
(Age from-to)	5	9							
	10	14							
	15	19							
	20	24							
	25	29							
	30	34							
	35	39							
	40	44							
	45	49							
	50	54							
	55	59							
	60	64							
	65	69							
	70	74							
	75	79							
	80	84							
	85	89							
	90	94							
	95	99							

Figure 1: Entering Variables ...

approximate remaining lifespan of a retiree. Row 10 contains the total fertility rate, the number of children a woman has over her lifetime. We start by assuming that fertility is 2.0, the current number for the United States. Row 11 is the start of working life, i.e., the average end of education time. I took 25 as the baseline estimate. Finally, row 12 contains the retirement age, which is assumed to be 65.

After having entered all this information, the next task is to simulate population over the next 100 years. To that end, I entered the boundaries of my age groups in columns `B` and `C` in rows 13 to 32. For this analysis, we disregard people over 100 years. In the year-2000 column you will enter the actual current population figures from the Web. From 2005 on, you will have to simulate population. The proper way of doing this would involve using precise death probabilities and birth rates at all ages. We will assume a simpler structure where people live for sure until they reach life-expectancy and then die immediately. Then the population in year x in the age group y equals the population in year $x-1$ in age group $y-1$, unless the age group is beyond the life-expectancy, in which case population in that age group is zero. In the spreadsheet, I did it the following way: The number of 5-9 year olds in 2005 is in cell `E14` in my spreadsheet. The formula for `E14` is given by `=D13*IF(E$9>$C14,1,0)`. Here `D13` is the number of 0-4 year olds in 2000, and the `IF` function checks whether the maximum age in the group `$C14` is smaller the life expectancy in 2005 `E$9`. If that is the case, the `IF` function is 1, so population equals `D13`, otherwise the `IF` function is 0, the population is 0. I will use the `IF(...,1,0)`-construct a lot, so make sure you understand how it works. When in doubt, use the help function in Excel. The dollar signs once again have the function to keep the cell references where they need to be once you copy the formula. You can copy the same formula to all years and age groups now. The only thing missing is a formula for the 0 to 4 year olds. I assume that people have half of their children when 25-29 years old, and the other half when 30-34 years old. We can then use the number of people in those age groups together with our assumptions on fertility rates to compute the number of children. Specifically, my formula for cell E13 (the 0 to 4 year olds in 2005) is given by =0.5*D10*(0.5*D18+0.5*D19). Here D10 is the total fertility rate in 2005, which is multiplied by 0.5 since the total fertility rate gives us children per woman, but we are using data on the whole population. This fertility rate per person is multiplied with the average of population in the 25-29 and 30-34 year age groups in 2000, which gives the number of 0-4 year olds in 2005. This formula can be copied to all the other years now. If you now enter the actual population data that you found on the web in the year-2000 column, your population projections until 2100 should pop up right away. If you want, you can add another row for total population, and experiment how changes in life-expectancy or fertility will affect size and makeup of the population. Figure 2 shows what population should look like with some artificial data.

The Future of Social Security

Wage growth per year: 0.015

Year			2000	2005	2010	2015	2020	2025	2030
Wage:			1	1.077284	1.160541	1.250232	1.346855	1.450945	1.56308
Benefit Ratio:			0.7	0.7	0.7	0.7	0.7	0.7	0.7
Life Expectancy:			80	80	80	80	80	80	80
Total Fertility Rate:			2	2	2	2	2	2	2
Start of Working Life:			25	25	25	25	25	25	25
Retirement Age:			65	65	65	65	65	65	65
Population:	0	4	0	10	10	5	0	0	0
(Age from-to)	5	9	0	0	10	10	5	0	0
	10	14	0	0	0	10	10	5	0
	15	19	0	0	0	0	10	10	5
	20	24	10	0	0	0	0	10	10
	25	29	10	10	0	0	0	0	10
	30	34	10	10	10	0	0	0	0
	35	39	10	10	10	10	0	0	0
	40	44	20	10	10	10	10	0	0
	45	49	20	20	10	10	10	10	0
	50	54	20	20	20	10	10	10	10
	55	59	5	20	20	20	10	10	10
	60	64	5	5	20	20	20	10	10
	65	69	5	5	5	20	20	20	10
	70	74	5	5	5	5	20	20	20
	75	79	5	5	5	5	5	20	20
	80	84	1	0	0	0	0	0	0
	85	89	1	0	0	0	0	0	0
	90	94	0	0	0	0	0	0	0
	95	99	0	0	0	0	0	0	0

Figure 2: . . . Adding Population . . .

The next task is to compute wages in the economy. If you have mastered all the steps so far, this should be relatively easy. In Figure 3 you see my spreadsheet with rows for wages at each age-group added. We only have to multiply population in each age group by the current wage, and set the wage to zero if the age group is either too young to work or already retired. For example, the formula for cell D33, the wages received by 0-4 year olds in 2000, is given by =D$7*D13*IF(D$11<$C33,1,0)*IF($C33<D$12,1,0). Here D7 is the wage in 2000, and D13 is the number of 0-4 year olds in 2000. The first IF function checks the minimum working age, and the second checks the retirement age. In the case of the 0-4 year olds, the first IF function returns a zero, therefore total wages are zero. By copying this function to all ages and years you can compute wages for each age group until 2100.

Finally, we have to compute retirement benefits. In the year 2000, the best thing would be to take actual current retirement benefits. For simplicity, I assume that the average retired person currently received 50 percent of what the average worker gets. With this number the current Social Security Tax will turn out to be what it is supposed to be. For example, in my spreadsheet the retirement benefits of 65-69 year

Population:	0	4	0	10	10	5	0	0	0
(Age from-to)	5	9	0	0	10	10	5	0	0
	10	14	0	0	0	10	10	5	0
	15	19	0	0	0	0	10	10	5
	20	24	10	0	0	0	0	10	10
	25	29	10	10	0	0	0	0	10
	30	34	10	10	10	0	0	0	0
	35	39	10	10	10	10	0	0	0
	40	44	20	10	10	10	10	0	0
	45	49	20	20	10	10	10	10	0
	50	54	20	20	20	10	10	10	10
	55	59	5	20	20	20	10	10	10
	60	64	5	5	20	20	20	10	10
	65	69	5	5	5	20	20	20	10
	70	74	5	5	5	5	20	20	20
	75	79	5	5	5	5	5	20	20
	80	84	1	0	0	0	0	0	0
	85	89	1	0	0	0	0	0	0
	90	94	0	0	0	0	0	0	0
	95	99	0	0	0	0	0	0	0
Wages:	0	4	0	0	0	0	0	0	0
(Age from-to)	5	9	0	0	0	0	0	0	0
	10	14	0	0	0	0	0	0	0
	15	19	0	0	0	0	0	0	0
	20	24	0	0	0	0	0	0	0
	25	29	10	10.77284	0	0	0	0	15.6308
	30	34	10	10.77284	11.60541	0	0	0	0
	35	39	10	10.77284	11.60541	12.50232	0	0	0
	40	44	20	10.77284	11.60541	12.50232	13.46855	0	0
	45	49	20	21.54568	11.60541	12.50232	13.46855	14.50945	0
	50	54	20	21.54568	23.21082	12.50232	13.46855	14.50945	15.6308
	55	59	5	21.54568	23.21082	25.00464	13.46855	14.50945	15.6308
	60	64	5	5.38642	23.21082	25.00464	26.9371	14.50945	15.6308
	65	69	0	0	0	0	0	0	0
	70	74	0	0	0	0	0	0	0
	75	79	0	0	0	0	0	0	0
	80	84	0	0	0	0	0	0	0
	85	89	0	0	0	0	0	0	0
	90	94	0	0	0	0	0	0	0

Figure 3: ...Computing Wages ...

olds in 2000 are in cell `D66`, and the formula for `D66` is `0.5*D$7*D26`. Here `D7` is the wage in 2000, and `D26` is the number of 65-69 year olds in 2000. From 2005 on, computing retirement benefits becomes more complicated. There are two different cases. The first possibility is that the age-group has just reached retirement age. In that case, the retirement benefits are given by the wages this age group received in the previous period, times the benefit ratio. On the other hand, if the age group was already retired in the previous period, retirement benefits are what they were in the previous period. For example, in my spreadsheet the retirement benefits of 65-69 year olds in 2005 are in cell `E66`. The formula for `E66` is given by `=E$8*D45*IF($B66=E$12,1,0)+D65*IF($B66>E$12,1,0)*IF($C66<E$9,1,0)`. The first part of the sum is for the case in which the retirement age has just been reached (`$B66=E$12`). In that case, pensions are former wages (`D45`) times the benefit ratio `E8`. The second part of the sum is for the case in which the people were already retired in he previous period. In that case, the benefits are equal to what they were before (`D65`), provided the age group is beyond retirement age (`$B66>E$12`) and below life expectancy (`$C66<E$9`). Copying this formula to all years and ages should bring up retirement benefits for all ages until 2100.

The rest is simple: Add a a row for total wages (in my case, the formula for `D74` is `=SUM(D33:D52)`) and another row for total retirement benefits (in my case, `D75` is `=SUM(D53:D72)`). Since current benefits are paid by taxes on current workers, the Social Security tax is the ratio of benefits to wages: Cell `D76` is given by `=D75/D74`. Now you only have to copy these formulas to all years, and you will see the future of the

Wages:	0	4	0	0	0	0	0	0	0
(Age from-to)	5	9	0	0	0	0	0	0	0
	10	14	0	0	0	0	0	0	0
	15	19	0	0	0	0	0	0	0
	20	24	0	0	0	0	0	0	0
	25	29	10	10.77284	0	0	0	0	15.6308
	30	34	10	10.77284	11.60541	0	0	0	0
	35	39	10	10.77284	11.60541	12.50232	0	0	0
	40	44	20	10.77284	11.60541	12.50232	13.46855	0	0
	45	49	20	21.54568	11.60541	12.50232	13.46855	14.50945	0
	50	54	20	21.54568	23.21082	12.50232	13.46855	14.50945	15.6308
	55	59	5	21.54568	23.21082	25.00464	13.46855	14.50945	15.6308
	60	64	5	5.38642	23.21082	25.00464	26.9371	14.50945	15.6308
	65	69	0	0	0	0	0	0	0
	70	74	0	0	0	0	0	0	0
	75	79	0	0	0	0	0	0	0
	80	84	0	0	0	0	0	0	0
	85	89	0	0	0	0	0	0	0
	90	94	0	0	0	0	0	0	0
	95	99	0	0	0	0	0	0	0
Pensions:	0	4	0	0	0	0	0	0	0
(Age from-to)	5	9	0	0	0	0	0	0	0
	10	14	0	0	0	0	0	0	0
	15	19	0	0	0	0	0	0	0
	20	24	0	0	0	0	0	0	0
	25	29	0	0	0	0	0	0	0
	30	34	0	0	0	0	0	0	0
	35	39	0	0	0	0	0	0	0
	40	44	0	0	0	0	0	0	0
	45	49	0	0	0	0	0	0	0
	50	54	0	0	0	0	0	0	0
	55	59	0	0	0	0	0	0	0
	60	64	0	0	0	0	0	0	0
	65	69	2.5	3.5	3.770494	16.24757	17.50325	18.85597	10.15662
	70	74	2.5	2.5	3.5	3.770494	16.24757	17.50325	18.85597
	75	79	2.5	2.5	2.5	3.5	3.770494	16.24757	17.50325
	80	84	0.5	0	0	0	0	0	0
	85	89	0.5	0	0	0	0	0	0
	90	94	0	0	0	0	0	0	0
	95	99	0	0	0	0	0	0	0
Total Population:			127	130	135	135	130	125	105
Total Wages:			100	113.1148	116.0541	100.0186	80.8113	58.03781	62.52321
Total Pensions:			8.5	8.5	9.770494	23.51807	37.52131	52.60679	46.51584
Year:			2000	2005	2010	2015	2020	2025	2030
Social Security Tax:			8.5%	7.5%	8.4%	23.5%	46.4%	90.6%	74.4%

Figure 4: . . . and, Finally, Computing Pensions and the Social Security Tax.

Social Security Tax. Figure 4 shows retirement payments and Social Security Taxes on my spreadsheet, with artificial population data.

Question 1:
For the following questions, please submit a copy of your spreadsheet. Graph Social Security Taxes for the baseline assumptions from the year 2000 to 2100.

Question 2:
Now produce graphs for future Social Security Taxes under the following alternative assumptions:

- Life expectancy rises to 90 from 2015 on, and the fertility rate falls to 1.5 at the same time and stays there (Remark: Even today countries like Italy and Japan have fertility rates below 1.5).
- Wages grow only at 0.5 percent per year.
- The retirement age is moved to 70 in 2010.
- The benefit ratio is lowered to 0.5 from 2010 on.

Generational Accounting

Read the article “An International Comparison of Generational Accounts,” by Laurence J. Kotlikoff and Willi Leibfritz. The article has been published as the NBER working paper No. 6447, and is available online under `http://nberws.nber.org/papers/W6447`. There is a link from the course home page. If you want, you can read the article “The Perils of Privatisation” from the Economist magazine as an introduction.

Question 3:
In no more than two paragraphs, explain the concept of generational accounts. How are they defined, and how are they computed?

Question 4:
The Ricardian view of government debt claims that government debt is irrelevant. Consider two countries, A and B. Both have the same future sequence of government spending, but A has government debt in the amount of 100% of GDP, while the government of country B is debt-free. According to the Ricardian view, does this difference in government debt have any real consequence? How would the high government debt in country A influence generational accounts? Does the Ricardian view of government debt cast doubts on the usefulness of the concept of generational accounts?