ABSTRACT

CHENG, YIJING. Underfunding of State and Local Pension Plans in the United States: The Role of the Dependency Ratio. (Under the direction of Lee Craig).

The underfunding of public sector pension plans in the United States is a potentially serious problem. According to analysis conducted by the Pew Center, as of 2008, there was a $1 trillion funding gap between the $2.35 trillion states and participating localities have set aside to pay for employees' retirement benefits and the $3.35 trillion value of their pension liabilities. Many observers have noted that the cause of the funding gap is the poor performance of the U.S. stock market since 2007. This performance reduced the returns on the assets in the pension fund portfolios and thus exacerbated the funding gap. However, my thesis focuses on another important factor—the dependency ratio, which is the ratio of pension fund beneficiaries to workers. Specifically, I focus on how the dependency ratio affects the funding ratio.

The data are from the Wisconsin Legislative Council, from 1990 to 2008 and they are reported every other year (except 1998). There are three linear regression models provided in this thesis. The results generated from the models suggest that there is a negative relationship between the funding ratio and the dependency ratio. I find that for every ten percentage point increase in the dependency ratio, there is a roughly 4.5 percent decrease in the funding ratio. In other words, besides the huge investment losses resulting from the large economic recession in the last a few years, the decreasing funding ratio over the last ten years has been at least partly driven by the increasing dependency ratio.

Underfunding of State and Local Pension Plans in the United States: The Role of the Dependency Ratio

by
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DEDICATION

致父母

谢谢你们一直在我身后支持我，鼓励我

(To my parents: Thank you for always being there

to support me and to encourage me)

BIOGRAPHY

Yijing Cheng was born in 1987 in Jinhua, a city in the middle of Zhejiang Province, which is in the southeast of the People's Republic of China. She grew up happily in this city, and finished her elementary, middle high and senior high school there. After graduating from Jinhua No. 1 Middle School, she went to Ningbo University to pursue the Bachelor's Degree. In her first year of university, she was registered as a student in the Department of Computer Science. After the first year of study, she realized that she did not like her major, and then she decided to transfer to the Department of Business. So after three years' study of International Economics and Trade, she successfully received the Bachelor's Degree of Economics in 2009. At the same time, she received an admission letter from the Department of Economics in North Carolina State University as a full-time graduate student. Since August in 2009 until now, she's been studying in this master's program of Economics.

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I also want to convey my appreciation to Professor Robert Clark from the Department of Economics and Professor Wenbin Lu from the Department of Statistics who are the other committee members who helped me with some questions regarding my thesis. In addition, I would like to thank Dr. Tamah Morant and Ms. Robin Carpenter, who offered me a lot of important information and helped with my two-year study and the graduation application as well.

And lastly, I want to thank my family for supporting me and encouraging me by all means, and all my friends to be there when I am upset or have any problem. Without them, I could not have obtained what I have now.

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By the end of the twentieth century, defined benefit retirement plans remained the major type of pension plans in the public sector in the United States; whereas in the private sector, defined contribution plans are the most prominent type of plan (Clark et al 2011, p. 159-160). With a defined benefit pension, public sector employees, such as those who work for states and municipalities, promise workers--including teachers, firefighters and policemen--a specified benefit at retirement. The benefit is predetermined by a formula, typically based on three things: the employee's earning history, years of service, and a multiplier or "generosity factor". So if all goes well, when the employees retire, they will receive the promised benefits from their employers. But what happens if the public employers face some type of financial crisis? Will the employees actually receive the full value of the promises they have received at or beyond the time of retirement?

An analysis by the Pew Center on the States[1] states that "at the end of fiscal year 2008, there was a $1 trillion gap between the $2.35 trillion the states and participating localities had set aside to pay for their employees' retirement benefits and the $3.35

[1] The Pew Center on the States is a division of The Pew Charitable Trusts that identifies and advances solutions to critical issues facing the states. It is a nonprofit organization that applies an analytical approach to improving the discussion and analysis of public policy, with the objective of informing the public and stimulating debate.

trillion price tag of those promises" (Pew Center, 2010, p.1). To be specific, in the fiscal year 2008, public employers have promised employees $3.35 in future benefits, but those employers can only have $2.35 in assets to make those payments. Thus there is a $1 trillion gap between these two figures, which means the retirees may not get fully paid as promised; or public employers, which means taxpayers, will have to increase their contributions to the plans; or current employees will have to increase their contributions; or some combination of these will be required to balance the plans' liabilities and assets. (Other estimates, using a different rate to discount future liabilities, place the gap as high as $2.5 trillion. See Rauh and Novy-Marx, 2011.)

Furthermore, Pew's figure is arguably conservative because it only calculates total assets in the public sector plans to the end of fiscal year 2008, which usually ends on June 30, 2008. So the downturn of the pension fund investments, which were subsequently affected by the worse economic environment in the second half year of 2008 were not shown in the figure. Another reason is that "most states' retirement systems allow for the 'smoothing' of gains and losses over time" (Pew Center, 2010, p. 1), which means that the effect of the losses in the investment returns will continue to erode the balance sheets of the public sector pension plans over the next couple of years. Because of these two reasons, the funding gap from Pew's analysis might be narrower than the actual gap and it will increase in the next few years.

This funding gap creates a potential crisis in the state's pension systems, which may cause many other problems. For example, employees may become dissatisfied with the states' systems, and fewer people will be attracted to work for public sector employers. Or if taxpayers are called upon to "bail out" the plans, the upward pressure on tax rates would create a deadweight loss and might discourage real economic activity, which would shrink the tax base and put even more upward pressure on tax rates, creating a potentially harmful spiral.

It is worth considering how the nation's state and local pension plans got in so much trouble. Pew's analysis also compared the current situation with that in 2000. There was no big shortfall in pension funding at the beginning of the twenty-first century; the problem began more recently. "In 2000, state-run pension plans were actually running a $56 billion surplus. From 2000 to 2008, growth in pension liabilities had outstripped growth in assets by more than $500 billion. In 2000, more than half the states were fully funded. By 2006, that number had shrunk to six states. By 2008, only Florida, New York, Washington and Wisconsin could make that claim" (Pew Center, 2010, p.16).

From Figure 1, we can see that in 1999 and 2000, the funding was quite strong, in that pension plans were 102% funded on average, which means that the assets could fully cover the liabilities in those years, and the public sector employees could expect to get fully paid. But as time went by, the increase of asset values did not

follow the increase in liabilities. In fiscal year 2008, the state systems were 84 percent funded in the aggregate. In other words, the assets could only cover 84 percent of the total liabilities, which yields the gap between assets and liabilities, which is the $1 trillion mentioned earlier.

Figure 1

According to the National Bureau of Economic Research, the recent recession began in December 2007. And it also affected the stock market severely. "In calendar year 2008, public sector pension plans experienced a median 25 percent decline in their investments" (Pew Center, 2010, p. 5). Therefore, many analysts and scholars argue that the $1 trillion gap between assets and liabilities was caused by the recession. Is this true? Partly. Refer back to Figure 1. Note that the gap between liabilities and assets from 2001 to 2007 is increasing all the time. So even before the recession, the state pension systems were underfunded, and had been for several years. In this case, the recession in 2007 might be a reason for making the funding situation worse; and it might be the most dominant reason why the gap is increasing; but it is not the only reason.

There is other evidence which shows that the economic recession is not the only cause of the funding gap. "States are performing dramatically differently in managing

this bill coming due. States such as Florida, Idaho, New York, North Carolina and Wisconsin all entered the current recession with fully funded pensions. But many other states are struggling. At the end of fiscal year 2008, 21 states had funding levels below the 80 percent mark, compared with 19 below that level in 2006" (Pew Center, 2010, p.17). The influence of the recession and the stock market is nationwide, but the performance of the states is quite different. In this thesis, I argue that there is at least one other major factor at work, one that differs state to state; one that affects the different performance of the states. In other words, the funding ratio might have a relationship with some other factors, which can be identified among different states. One of these which I look at is the "dependency ratio", which is the ratio of the number of dependents of a pension plan to its current contributors. In other words it is the ratio of retirees (who receive a pension) to employees (who contribute to the pension fund).

Model

The funding ratio provides valuable information about the actuarial soundness of a pension fund, and is thus of much interest to us. In the model that follows I propose to explain the behavior of the funding ratio in state-managed pension funds in the United States. Recall that the funding ratio is the ratio of assets held by the pension fund to the present value of fund liabilities – that is the promises to the employees. If a state's system is fully funded, then the funding ratio is 1 or greater than 1. In general, the larger the funding ratio, the better funded is the state's pension plan. I'm interested in how the funding ratio is related to other factors. Henceforth, I refer to the funding ratio as "FRATIO".

A variable that plays a role in explaining the behavior of the funding ratio is the dependency ratio, which, again, is the ratio of beneficiaries to workers – i.e. "it is the number of retirees dependent on benefits relative to the number of workers supporting them" (Scheiber and Shoven, 1999, p.72). If the dependency ratio is 1, it means that for every retiree receiving a pension from a particular fund, there is one employee contributing to the fund. Of course this scenario is unlikely to happen in real world. Conversely, if the dependency ratio is zero, there are no retirees receiving a benefit from the fund. The larger the dependency ratio, the larger is the number of retirees per employee.

To see the relationship between the dependency ratio and the funding ratio, consider the simple "pay-as-you-go" retirement system, in which the total benefits paid to the employees every year, which are expenditures for the pension system, have to be equal to the total contributions collected. In other words, "The amount of benefits paid is equal to the total number of people getting benefits times the average benefit paid by the system" (Scheiber and Shoven, 1999, p.72). The amount of contributions, from workers and employers, available to the system is equal to the contribution rate, including both the employer and employee portion of the contribution, times the number of workers who contribute to the fund, times workers' average earnings.

Although most public sector retirement plans in the United States do not operate on a pay-as-you-go basis, the basic model will help set up the connection between the dependency ratio and the funding ratio. The math of such a system is shown in equation [1] below. The required contribute rate to support such a system is the product of the relative number of beneficiaries and workers times the ratio of average benefits to average covered earnings, which is shown in equation [2].

The Mathematical Operations of an ideal Retirement Plan

Contributions = Expenditures

$$[1] \qquad c \cdot N_W \cdot W = N_B \cdot B$$

where:

c = contribution rate paid by employers and employees

N_W = number of covered workers employed in a year

W = average wages of workers during the year

N_B = number of retirees receiving benefits

B = average benefits paid to retirees

and such that:

$$[2] \qquad c = (N_B / N_W) \bullet (B / W)$$

So the dependency ratio in this simple model is the ratio of beneficiaries to workers (N_B / N_W); while (B / W) is the ratio of average benefits to average wages in a retirement, which is often referred to as the "replacement rate" – "it reflects how much of an average worker's earnings are replaced by the retirement benefit when he or she retires" (Sylvester, 1999, p.72). As a result, the contribution rate equals the product of the dependency ratio and the replacement rate.

Equation [2] shows that if the dependency ratio increases, then either the contribution rate must increase, or the replacement rate must decrease. In the United States, on average, for many public sector pension plans, the replacement rate has increased over time. "In 1982 the mean replacement rate for teachers was 53.0 percent. By 2006, the mean replacement rate had risen by more than five percentage points

(that is, roughly 10 percent) to 58.5 percent" (Clark et al., 2011, p. 88). So we can see that if the replacement rate has been increasing, then either the contribution rate will increase or the dependency ratio must decrease.

Of course, this model is a simplification. The creation of a pension fund complicates matters, because the funding strategy of the employer might be very complex. In what follows it might be best to think of the changes in the funding ratio as a response to unanticipated changes in the dependency ratio, since presumably anticipated changes would have already been a part of the employer's funding strategy[2].

We now connect this relationship to the funding ratios of the state-managed plans. Recall that the funding ratio is the ratio of assets to the present value of liabilities. The denominator is a function of the dependency ratio, in that if the dependency ratio goes up (i.e. there are more beneficiaries given the same number of workers), holding other variables constant, then the system has to pay more to the retirees and the present value of liabilities increases. So if the value of fund assets stays the same, the funding ratio will decrease as the dependency ratio increases.

But the assets in the numerator are mathematically linked with worker and employer contributions. At any point in time the current assets are a function of past contributions and earnings from the fund.

[2] I thank Professor Robert Clark for pointing out this issue

[3] $\text{Asset}_t = (\rho_{t-1} * \text{Assets}_{t-1}) + \text{Asset}_{t-1} + \text{Contributions}_{t-1} - \text{Distributions}_{t-1}$

Like in Equation [3], the amount of assets in *t*th period is the summary of the investment returns of the *(t-1)*th period, the amount of the assets in the *(t-1)*th period, the contributions of employers and employees in the *(t-1)*th period, and then minus the distributions in *(t-1)*th period – that is the payments from the fund to retirees. Specifically, ρ_{t-1} is the rate of investment returns in the *(t-1)*th period, so (ρ_{t-1} * Assets_{t-1}) is the increased investment from the asset in *(t-1)*th period. And the distributions include the money paid to the retirees and other management and administrative costs.

So if employers and employees contribute more to the fund, ceteris paribus, the system has more assets, and from equation [2] above we already know that the contribution rate will increase as the dependency ratio increases, holding the replacement rate constant. (And since we know the replacement rate has on averaged increased over time, this puts further upward pressure on the contribution rate.) So holding earnings on the fund's assets constant, the numerator of the funding ratio should increase as the dependency ratio increases, through higher contribution rates. However, if contribution rates do not increase enough to offset the increase in the dependency ratio, then the funding ratio will decrease, again holding other things

constant. Consequently, we now see how the funding ratio is related to the dependency ratio. What we now need is to estimate the size of this relationship.

Henceforth, I will use the name "DEPRATIO" to represent dependency ratio. Then I will build a linear model using FRATIO and DEPRATIO as the dependent and independent variables, respectively.

[4] $$FRATIO_{it} = \alpha + \beta_1 DEPPRATIO_{it} + e_{it}$$

Specifically, $FRATIO_{it}$ is the funding ratio of the *i*th state in *t*th year in the United States; $DEPRATIO_{it}$ is the dependency ratio of the *i*th state in *t*th year; and e_{it} is the error of the model for every *i* and *t*, and e_{it} has a mean of zero and a finite variance. As for the coefficients, α is the intercept of the model, and β_1 is the coefficient of the variable DEPRATIO, i.e. it tells us the size of the relationship between the dependency ratio and the funding ratio. If we cannot reject the hypothesis that $\beta_1 = 0$, it means that $FRATIO_{it}$ has no relationship with $DEPPRATIO_{it}$. In other words, such a result would lead me to conclude that the funding ratio for the state pension plans in my sample has no linear relationship with dependency ratio. If however $\beta_1 > 0$, then the funding ratio has a positive relationship with dependency ratio, which means that if the dependency ratio increases, the funding ratio will also increase. Given our theoretical discussion above, we do not expect to find this. If

however $\beta_1 < 0$, the funding ratio will decrease as dependency ratio increases, the finding suggested by our model above. So from this model, we can see how the funding ratio changes as dependency ratio changes.

Considering that there are some other factors – other than the stock market, of course – which may also influence the funding ratio, I will add some other variables in model shown in equation [4]. The first other variable I will add is "BenefitValue", which is the formula multiplier or generosity factor in the pension plan. Since the formula multiplier determines the pension annuity payment an employee will receive from their employer, it will affect the denominator of funding ratio, ceteris paribus. So my hypothesis is "BenefitValue" also has a relationship with "FRATIO".

The multipliers vary from plan to plan. "There are a wide range of formula multipliers in effect for these 70 plans [the plans in the Wisconsin sample that are "coordinated" with Social Security], which sometimes vary by number of years of service, by date of employment, or by age at retirement. For 2008, the average formula multiplier for the coordinated plans that are not money purchase plans, defined contribution plans, or plans in which the employer determines the formula multiplier is approximately 1.94%" (Schmidt, 2009, p. 26). In 2002, the average formula multiplier was 1.99%. BenefitValue_{it} is the formula multiplier of the *i*th state in *t*th year. Thus, the new model is:

[5] $FRATIO_{it} = \alpha + \beta_1 DEPPRATIO_{it} + \beta_2 BenefitValue_{it} + e_{it}$

Running this model will yield the estimates of α, β_1 and β_2. The explanation of α and β_1 is the same as in the first model as shown in equation [4]. As for β_2, if it is positive, it means that as the formula multiplier increases, funding ratio will also increase. If, however, β_2 is negative, it shows that funding ratio has a negative relationship with the formula multiplier. Because an increase in the multiplier will increase pension liabilities, ceteris paribus, my hypothesis is that β_2 is negative.

Besides the signs of β_1 and β_2, I will also see whether they are statistically significant in this model, that is I want to test the hypotheses: $\beta_1 = 0$ and $\beta_2 = 0$. If β_1 is statistically significant in this model, it means that the dependency ratio has a statistically significant influence on the funding ratio. In addition, I am interested in the size of the impact of the left-hand side variables on the funding ratio.

As our simple model above suggests, another important factor which may influence funding ratio is employee contribution rates. "Most public employee pension plans at least nominally require employees to contribute a certain percentage of their salary to the plan, although some public employee pension plans provide for employer 'pick-up' of the employee contribution" (Schmidt, 2009, p.19). So the employee contribution rate is shown as a percentage of salary, or it is the ratio of the contribution employee put into the pension fund relative to the employee's annual

salary. As Clark et al. note, "We also analyzed employee contribution rates, which vary from a low of zero – in Florida, Tennessee and Utah – to a high of 11.0 percent in Massachusetts. Between 1984 and 2006, 22 states increased employee contributions while nine states reduced the employee contributions rate" (Clark et al., 2011, p. 96). Also, "It appears most of the increase in employee contribution rates occurred before 2002, as Brainard (2007), using a survey of plan administrators, reports, as the mean employee contribution rates remained stable between 2002 and 2006. The employee contribution rate for states with Social Security coverage was 5.0 percent during this later period and the contribution rates for employees that were not part of Social Security was 8.0 percent" (Clark et al., 2011, p.112).

The column in [Table 1] entitled "Employee Contribution" shows the employee contribution rates, expressed as a percentage of payrolls, for the 85 state-managed plans covered in the report of Wisconsin Legislative Council in 2008.

So in the new model, there are now three independent variables: dependency ratio, formula multiplier and employee contribution rates.

[6] $FRATIO_{it} = \alpha + \beta_1 DEPPRATIO_{it} + \beta_2 BenefitValue_{it} + \beta_3 EmployeeCont_{it} + e_{it}$

where $EmployeeCont_{it}$ is the employee contribution rate in the *i*th state in *t*th year.

In the next section I discuss the data used to run the three models, and in section four I will present the results, focusing on the sign, statistical significance, and size of the independent variables to better understand the relationship between them.

Data

In this thesis, I employ data on the "major" state-managed public employee retirement systems in the United States. These data are from 85 of pension plans that cover teachers, other state employees, and in some cases local employees as well. By "major" plans, I mean the largest plans. Although there are more 2,500 state and local pension plans in the United States (219 of which are state-managed), the 85 plans in my sample represent the vast majority of state workers as well as the majority of local workers. For example, Clark et al. note that 60 percent of local workers covered by a plan are covered in the state-managed plans in the Wisconsin Legislative Council data. The data are from the Wisconsin Legislative Council[3], from 1990 to 2008 and they are reported every other year (except 1998).

There are 85 plans in 9 years from 1990 to 2008 in the original data, which gives me 765 observations. Then I deleted the observations with missing values of employee contribution or benefit value (i.e. generosity parameter), so one or more pension plans in the following states are missing data for one or more years: Arkansas,

[3] The Legislative Council is one of five nonpartisan legislative service agencies of the Wisconsin Legislature. The staff is headed by Director Terry C. Anderson who reports to the Joint Legislative Council and the Joint Committee on Legislative Organization.

California, Delaware, Florida, Georgia, Hawaii, Iowa, Kentucky, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, Oklahoma, Rhode Island, Tennessee, Texas, Utah, Vermont, and Wisconsin. Finally, following this process, I ended up with 402 observations in my sample, and I sorted the final data by year and state.

From the original data, which provided much information on the state-managed pension plans, I am interested in the following: Year, State, FundName, EmployeeCov (i.e. what kind of employee does the plan cover); SSCoverage (if social security is covered in the plan, then this variable equals 1; otherwise it is 0); EmployeeCont (Employee Contribution rate, from 0 to 1); BenefitValue (formula multiplier in a pension fund); FundRatio (i.e. the ratio of assets to the present value of liabilities, displayed in percent); and the DepRatio (dependency ratio). Then I add a new variable "New_Fundratio", which displays FundRatio as a percentage – i.e. 95 rather than 0.95. I also created a set of dummy variables Dum1990, Dum 1992 …… Dum2008, which represent the years.

To get a general idea of what the data look like, I generated descriptive statistics for the variables. See [Table 2]. The data in [Table 2] show that the average funding ratio in 2008 (0.796) is far less than the overall pool average from 1990 to 2008 (0.888), which means the underfunded situation has gotten more serious in recent years. Also note that the dependency ratio has increased 61.7 percent, from 0.329 in

1990 to 0.532 in 2008. This change is driven by the much faster increase in retirees than workers. (See Table 7, below.)

[Table 2]

I also generated a figure to show how the mean values of these variables developed from 1990 to 2008. In Figure 2, from the top to the bottom, they display the development of the funding ratio, dependency ratio, formula multiplier and employee contribution rate from 1990 to 2008, in the state-managed plans of my sample.

With respect to the funding ratio, the figure shows a rapid increase from about 1997 to 2002, as the stock market performed well during that time. "Defying skeptics and historical precedent, the U.S. stock market soared again in 1997, allowing the Dow Jones industrial average to post a gain of more than 20 percent for the third consecutive year. It was a feat never before accomplished" (Myers, February 1998, p. 21). And recall Equation [3] in Section 2, because the rate of investment returns is high due to the soaring stock market during that time, the value of the assets in the pension fund is also large. Therefore, the funding ratio increases rapidly after 1997. Then it reached the peak in 2000, and faced a deep downturn after that. From September 2000 to January 2, 2001, the NASDAQ dropped 45.9 percent. In October

2002, the NASDAQ dropped to as low as 1,108.49 – a 78.4 percent decline from its all-time high of 5,132.52, the level it had established in March 2000. The ups and downs of the stock market clearly affected the funding ratio.

Now let us look at the most independent variable in our model – the dependency ratio. It increases all the time, and in 1996, the increasing rate got a bit higher than ti had been and even higher in 2002, until 2004.

As for the other two variables, the employee contribution bounced twice and came back to the same level as in 1990. The mean formula multiplier remained almost roughly constant from 1990 to 2008.

Figure 2

Results

A reminder: for convenience of interpretation, I express the funding ratio in percentage terms and refer to it as "New_Fundratio". In addition, I have added the dummy variables to the base model, as reported in equation [4]; so the model I actually estimate is:

[7] $New\_Fundratio_{it} = \alpha + \beta_1 DEPPRATIO_{it} + \gamma_1 Dum1990 + \gamma_2 Dum1992 + \gamma_3 Dum1994 + \gamma_4 Dum1996 + \gamma_5 Dum2000 + \gamma_6 Dum2002 + \gamma_7 Dum2004 + \gamma_8 Dum2006 + e_{it}$

The results from estimating model (7) are shown in [Table 3]. The estimated value of β_1 – i.e. the impact of the dependency ratio on the funding ratio is -0.45567 (0.18767). (Standard errors are in parentheses.) In other words, if in *i*th state in *t*th year the dependency ratio increases by ten percentage points, which is less than one standard deviation from the mean (from [Table 3]), the funding ratio will decrease by 4.5 percentage points. I would argue that, in addition to being statistically significant, the finding is economically significant, perhaps the equivalent of one year of liability payments.

To explain the negative sign of β_1, I argue that if there are more retirees given the same number of workers, i.e. if the dependency ratio increases, then the underfunded situation will get worse. To see this, refer back to Section 2; the dependency ratio equals beneficiaries divided by current employees, and the funding ratio equals assets divided by liabilities. Thus, if beneficiaries increase relative to employees (who make contributions to the fund, which increases assets), then, ceteris paribus, there will be fewer contributions to assets in the numerator of the funding ratio, relatively speaking of course, and more liabilities in the denominator.

As noted in Section 3, the dependency ratio has been increasing; so the present value of liabilities is also increasing. And the amount of assets increases as the contribution increases, again, ceteris paribus, which has a positive impact on the funding ratio. But the funding ratio has been decreasing; so it follows that contributions have not increased enough to keep up with the decrease in assets from other causes (for example, the general decline in the value of financial assets during the recent recession). (Clark et al. agree with this point (2011, p. 112)). Thus asset values have fallen as liabilities have increased. In short, increases in contribution rates cannot keep up with increases in retirees, holding other variables constant.

[Table 3]

The t value of the estimated β_1 is -2.43, and the probability of the value that is greater than the absolute value of t is 0.0156, which is smaller than 5 percent. So I can reject the null hypothesis that the value of β_1 is zero, at the 5 percent level. Literally, the dependency ratio can negatively affect the funding ratio in both economically and statistically significant ways, regardless of what is happening in the stock market!

Now let us add another variable, BenifitValue, to model (4), which yields model (5):

[8] $New\_Fundratio_{it} = \alpha + \beta_1 DEPPRATIO_{it} + \beta_2 BenifitValue + \gamma_1 Dum1990 + \gamma_2 Dum1992 + \gamma_3 Dum1994 + \gamma_4 Dum1996 + \gamma_5 Dum2000 + \gamma_6 Dum2002 + \gamma_7 Dum2004 + \gamma_8 Dum2006 + e_{it}$

From [Table 4], I get the estimated value of β_1 as -0.44472 (0.18888), which in absolute value is a little smaller than the one in the model as expressed in equation [7]. In other words, if in the *i*th state in the *t*th year the dependency ratio increases by ten percentage points, which, again, is less than one standard deviation from the mean, and then the funding ratio will decrease by 4.4 percentage points. Again, I argue that this result is statistically and economically significant. The t value of the estimated β_1 is -2.35, and the probability that the value is greater than the absolute value of t is

0.0190, which is smaller than 5 percent. So, again I conclude that the estimated value of β_1 is statistically significant on the 5 percent level.

[Table 4]

As for the coefficient of "BenefitValue" – i.e. the generosity parameter of benefit multiplier in the defined benefit pension plan – β_2; in the model, the estimated value is -4.09132 (7.39979). So, keeping the dependency ratio constant, if the formula multiplier increases for 0.1, which would be a rather large increase (see [Table 4]) the funding ratio will decrease 0.409132, which, would seem to be an economically significant amount, though considerably smaller than the impact of the dependency ratio. However, the t value is only 0.55, and the probability of obtaining a value that is greater than the absolute value of t is 0.5806, which is much greater than 10 percent. So the estimated value of β_2 is not statistically significant – that is to say, I cannot reject the hypothesis that β_2 is zero. In any case, it is worth discussing the negative sign of β_2. It says, in essence, if the formula multiplier increases, then employers will promise to pay more to the beneficiaries, which will increase the present value of liabilities. So the funding ratio will decrease.

Now let's add the third variable Employee Contribution Rate (EmployeeCont) and build model (6), as shown in equation [9]:

$$[9]\ New\_Fundratio_{it} = \alpha + \beta_1 DEPPRATIO_{it} + \beta_2 BenifitValue + \beta_3 EmployeeCont + \gamma_1 Dum1990 + \gamma_2 Dum1992 + \gamma_3 Dum1994 + \gamma_4 Dum1996 + \gamma_5 Dum2000 + \gamma_6 Dum2002 + \gamma_7 Dum2004 + \gamma_8 Dum2006 + e_{it}$$

From the results in [Table 5], I obtained an estimated value of β_1 as -0.44475 (0.18912), which is almost the same as found in the earlier estimates. So the discussion is similar. Besides, the estimated value of the coefficient of Employee Contribution is 0.00542 (0.06221). This means that, keeping the dependency ratio and formula multiplier unchanged, if the employee contribution increases by 10 percentage points, the funding ratio will increase 0.000542. This would seem to be a rather low number, and hence I conclude the impact of this variable is not economically significant. Furthermore, the probability of the value that is greater than the absolute value of t is 0.9307, which is much greater than 10 percent. So, like the benefit multiplier, it is not statistically significant.

[Table 5]

From all the results above, I can conclude that the estimated value of β_1 is between -0.44 and -0.46, which means that no matter whether the formula multiplier and employee contribution affect the funding ratio or not, the estimated value of the coefficient of dependency value is in the neighborhood of -0.45, and it is consistently statistically significant. This result provides evidence to support the arguments I made earlier in this thesis; that is, specifically, besides the huge investment losses resulting from the large economic recession in the last a few years, the decreasing funding ratio in the last 10 years has been at least partly driven by the increasing dependency ratio[4]. Since many observers and scholars focus on the poor performance of the stock market of recent years, my work suggests that we should transfer our attention to another component of the reason that the state-managed pension plans are underfunded. From the results of this thesis, I conclude the increasing dependency ratio is also an important cause of the huge funding gap.

[4] Of course the variables in our model are not independent of one another. In particular, workers who are part of underfunded pensions might anticipate future changes to the plan – for example, an increase in contribution rates, or a decrease in benefits – that might cause them to retire early, which makes the problem even worse. However, analyzing such issues goes beyond this thesis and must be a topic for future study. I thank Professor Wenbin Lu for pointing out this issue.

Conclusions

Scholars and others studying the recent "crisis" in the funding of state and local pension plans in the United States have focused on the performance of the stock market since 2007. In contrast, this thesis analyzes the relationship between the funding ratio (i.e. the ratio of pension plan assets to liabilities) of state-managed pension plans and dependency ratio (i.e. the ratio of plan beneficiaries to workers). Using the data on the major public employee retirement systems, which are provided by Wisconsin Legislative Council from 1990 to 2008, I show that one of the key reasons many state-managed retirement systems are currently so underfunded is because of the movement in the dependency ratio, which worsened the funding status of the plans in my sample.

As noted in section 1, there is currently a funding gap in state managed pension plans. Estimates of the size of this gap range from $500 billion to several trillion dollars, which means that the underfunded situation in the major public employee retirement systems is really severe. From the data I employed in this study, the mean funding ratio in 2008 was 0.796; while the mean ratio between 1990 and 2008 was 0.888. Thus roughly 20 percent of the aggregate pension liabilities of the state-managed pension funds could not currently be paid to the retirees. "Between the start of the recession in December 2007 and November 2009, states faced a combined

budget gap of $304 billion, according to the National Conference of State Legislatures (NCSL). And revenues are expected to continue to drop still more during the next two years. Under these conditions, many states have been and will continue to be forced to make difficult decisions about where to invest their limited resources" (Pew Center, 2010, p. 22-23).

Since the onset of the recent recession, the stock market has declined substantially. The Dow Jones Industrial Average closed at 14,164 on October 9, 2007 and has not come close since. It bottomed out below 6,600 in March 2009, a peak to trough decline of more than 53 percent and currently remains around 12,000. So the investment returns of the retirement systems have been decreasing, which to some extent causes the value of assets to diverge from the present value of liabilities, holding other factors constant. As noted, many people have already noticed and studied the impact of the stock market. (Clark et al. show the importance of stock market investments in the portfolios of public sector pension funds (2011, pp. 180-194).) However, this is not the only factor influencing the funding ratio. Instead, I'm looking at the relationship between dependency ratio and funding ratio.

Since the funding ratio is the ratio of assets in the fund to the present value of liabilities, and as described in section 2, an increase in the dependency ratio will tend to worsen the funding ratio, ceteris paribus, by increasing the present value of liabilities relative to assets, again, ceteris paribus. With respect to the dependency

ratio, an increase in retirees, ceteris paribus, increases the ratio and decreases the funding ratio; whereas an increase in workers, again ceteris paribus, decreases the dependency ratio but increases the funding ratio through increased contributions. As we cannot determine unambiguously how the funding ratio changes as the dependency ratio changes, I chose to employ econometrics to analyze the impact of the dependency ratio on the funding ratio, controlling for other factors.

From section 4, we see that in the linear regression models the coefficient on the dependency ratio is between -0.44 and -0.46, which suggests: (1) that funding ratio has a negative linear relationship with the dependency ratio, and (2) that for every ten percentage point increase in the dependency ratio, there is a roughly 4.5 percent decrease in the funding ratio. Thus I argue the impact of an increasing dependency ratio is both statistically and economically significant. As a result, I conclude the increasing dependency ratio is an important factor that negatively affects funding ratio.

As the dependency ratio is the number of beneficiaries relative to the number of workers, there are four ways in which the dependency ratio can increase. One is an increase in the number of beneficiaries (retirees); another is a decrease in the number of workers. A third is an increase in both variables with the number of beneficiaries increasing more than the number of workers; and the fourth is a decrease in both variables with the number of workers decreasing by more than the number of

beneficiaries. Of course, if the number of beneficiaries increases and the number of workers decreases, then the dependency ratio will increase even more rapidly.

One possibility for this final scenario, the one in which the dependency ratio increases rapidly, is if employees in the public sectors are aging. Year by year, as workers leave the labor force permanently, then they become retirees; so the number of workers decreases and at the same time, the number of retirees increases. If the workers who retire are not replaced at the same rate they retire, then the ratio of retirees to workers will increase. And this situation describes what has been happening to state and local government employment during the recent recession.

Turning to the Wisconsin Legislative Council data on this point, Table 6 shows that there are 21 state or local pension funds that have larger a dependency ratio in 2008 than they did in 1990.

[Table 6]

From Table 7, we can see that in general the pension funds in the Wisconsin data set have a greater dependency ratio in 2008 than they did in 1990, with the ratio increasing by roughly 50 percent. That figure is for all plans. However, in the plans that have seen the ratio increase, the increase has been on average greater than 70 percent! The average number of beneficiaries in those plans has increased by 116.70

percent, from 27,456 to 59,497; while at the same time, the average number of workers has increased by only 25.95 percent, from 96,214 to 121,184. Obviously, the increase in the number of beneficiaries is almost three times larger than the increase in number of workers. This then is what drives up the dependency ratio from 1990 to 2008.

[Table 7]

Therefore, if the dependency ratio keeps going up in the future, even if the stock market gets better, or the contributions increase, or the formula multiplier remains unchanged, or even goes down, the underfunded situation in the public sector pensions in the United States will still get worse with the increase in the dependency ratio, ceteris paribus. It follows that how to prevent the dependency ratio from rising might be an important subject in the future research.

Tables

Table 1: Employee Contribution Rates in 2006 and 2008

Employee Contribution Rages	2006	2008
5% or less	28 plans	30 plans
More than 5%	45 plans	46 plans
Rate varies (usually by age or employee classification)	6 plans	5 plans
Plan is noncontributory	6 plans	6 plans
Total	**85 plans**	**87 plans**

Source: Wisconsin Legislative Council

Table 2 : Descriptive Statistics: Means and Standard Deviations of the Data

Variable	1990	2008	Pooled from 1990 to 2008
Dependent variable:			
New_fundratio (Funding Ratio displaying in digital number)	0.815 (0.222)	0.796 (0.157)	0.888 (0.516)
Independent variables:			
DepRatio (Dependency Ratio)	0.329 (0.113)	0.532 (0.153)	0.426 (0.152)
BenefitValue	0.019 (0.003)	0.020 (0.004)	0.019 (0.003)
EmployeeCont (Employee Contrition Rate)	0.060 (0.014)	0.058 (0.018)	0.089 (0.412)

Source: Wisconsin Legislative Council

Table 3: Linear Model of Funding Ratio with Dependency Ratio, from 1990 to 2008

Dependenct Variable	New_Fundratio	t value	Pr > |t|
Intercept	1.03881*** (0.12334)	8.42	<.0001
DepRatio (Dependency Ratio)	-0.45667** (0.18767)	-2.43	0.0156
Dum1990	-0.07353 (0.11683)	-0.63	0.5295
Dum1992	-0.06397 (0.11180)	-0.57	0.5675
Dum1994	-0.0006 (0.11141)	-0.01	0.9955
Dum1996	0.03025 (0.10844)	0.28	0.7805
Dum2000	0.30992*** (0.10710)	2.89	0.0040
Dum2002	0.06456 (0.10712)	0.60	0.5470
Dum2004	0.09180 (0.10328)	0.89	0.3746
Dum2006	0.00320 (0.10255)	0.03	0.9752
R2 (adj)	0.0350		
F	2.61		
N	402		

*** -- The probability of obtaining a test statistic this large when the null hypothesis is true is 0.01;
** -- 0.05; * -- 0.10.

Table 4: Linear Model of Funding Ratio with Dependency Ratio and Benefit Value, from 1990 to 2008

Dependenct Variable	New_Fundratio	t value	Pr > |t|
Intercept	1.11420*** (0.18394)	6.06	<.0001
DepRatio (Dependency Ratio)	-0.44472** (0.18888)	-2.35	0.0190
BenefitValue	-4.09132 (7.39979)	-0.55	0.5806
Dum1990	-0.07598 (0.11702)	-0.65	0.5165
Dum1992	-0.06647 (0.11199)	-0.59	0.5531
Dum1994	-0.00252 (0.11156)	-0.02	0.9820
Dum1996	0.02737 (0.10866)	0.25	0.8012
Dum2000	0.30791*** (0.10725)	2.87	0.0043
Dum2002	0.06597 (0.10724)	0.62	0.5388
Dum2004	0.09222 (0.10337)	0.89	0.3729
Dum2006	0.00342 (0.10265)	0.03	0.9735
R2 (adj)	0.0333		
F	2.38		
N	402		

*** -- The probability of obtaining a test statistic this large when the null hypothesis is true is 0.01;
** -- 0.05; * -- 0.10.

Table 5: Linear Model of Funding Ratio with Dependency Ratio, Benefit Value and Employee Contribution, from 1990 to 2008

Dependenct Variable	New_Fundratio	t value	Pr > |t|
Intercept	1.11451*** (0.18421)	6.05	<.0001
DepRatio (Dependency Ratio)	-0.44475** (0.18912)	-2.35	0.0192
BenefitValue (Formula Multiplier)	-4.12146 (7.41728)	-0.56	0.5788
EmployeeCont (Employee Contribution)	0.00542 (0.06221)	0.09	0.9307
Dum1990	-0.07603 (0.11717)	-0.65	0.5168
Dum1992	-0.06652 (0.11213)	-0.59	0.5533
Dum1994	-0.00333 (0.11209)	-0.03	0.9763
Dum1996	0.02733 (0.10880)	0.25	0.8018
Dum2000	0.30715*** (0.10774)	2.85	0.0046
Dum2002	0.06589 (0.10738)	0.61	0.5398
Dum2004	0.09223 (0.10350)	0.89	0.3734
Dum2006	0.00341 (0.10278)	0.03	0.9735
R2 (adj)	0.0308		
F	2.16		
N	402		

*** -- The probability of obtaining a test statistic this large when the null hypothesis is true is 0.01;
** -- 0.05; * -- 0.10.

Table 6: The State or Local Pension Plans, Which Have Larger Dependency Ratio in 2008 than in 1990

State	FundName	Depratio in 1990	Depratio in 2008
Alabama	ERS	0.2559	0.3917
Alabama	TRS	0.2374	0.4729
Arkansas	TRS	0.2690	0.3819
Connecticut	TRS	0.3395	0.5564
Georgia	TRS	0.2047	0.3494
Idaho	PERS	0.3545	0.4630
Indiana	PERF	0.2547	0.4345
Louisiana	SERS	0.3892	0.6082
Milwaukee City		0.5752	0.9569
Minnesota	PERA	0.2801	0.4201
Montana	TRS	0.4196	0.6444
New Mexico	ERA	0.2517	0.4897
North Carolina	LGERS	0.1967	0.3314
North Dakota	PERS	0.1485	0.3543
North Dakota	TRF	0.3948	0.6607
Pennsylvania	SERS	0.6632	0.9755
South Carolina	SCRS	0.2410	0.5368
Texas	ERS	0.2030	0.5399
Texas	TRS	0.2508	0.3434
Virginia	SRS	0.2887	0.3945
West Virginia	PERS	0.4689	0.5892
Total/Mean	**21**	**0.3184**	**0.5188**

Table 7: Mean values of the number of beneficiaries and workers for all of the pension plans and those have larger dependency ratio in 2008 than in 1990

1 All pension plans

Year	Beneficiaries	Workers	Dependency Ratio
1990	2,973,311	8,929,950	0.333
2008	6,002,982	12,029,028	0.499

2 Pension plans those have larger dependency ratio in 2008 than in 1990

Year	Beneficiaries	Workers	Dependency Ratio
1990	27,456	96,214	0.285
2008	59,498	121,184	0.491

Figures

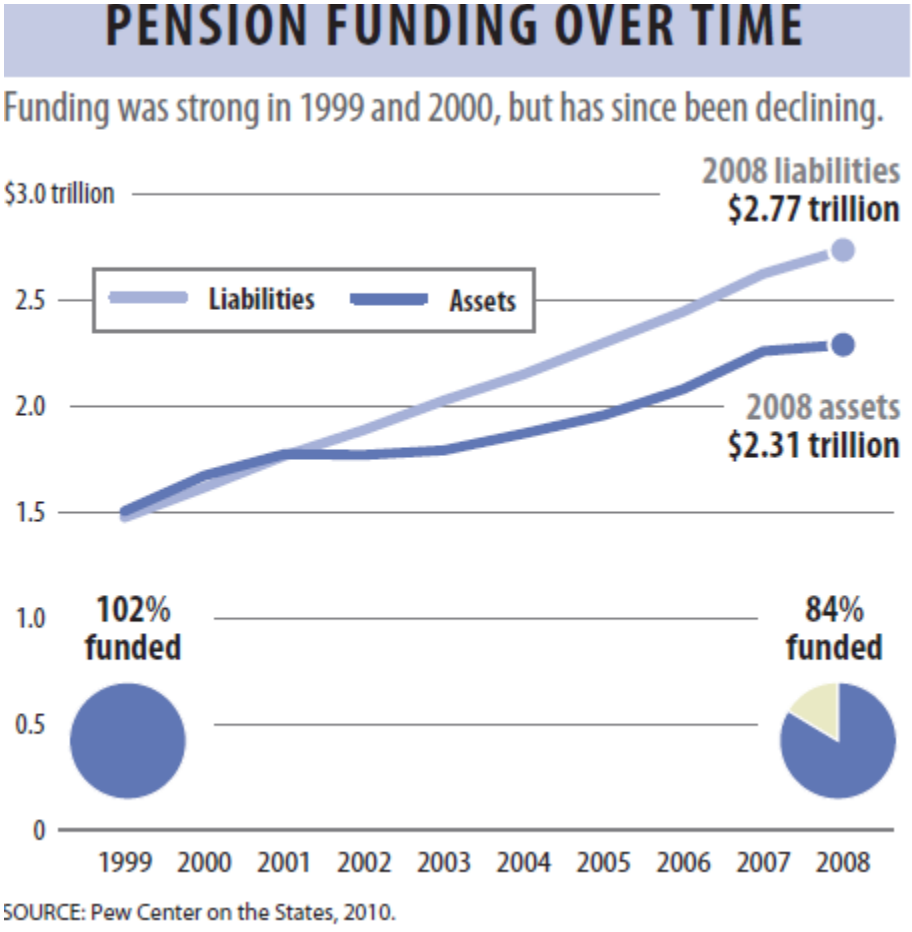
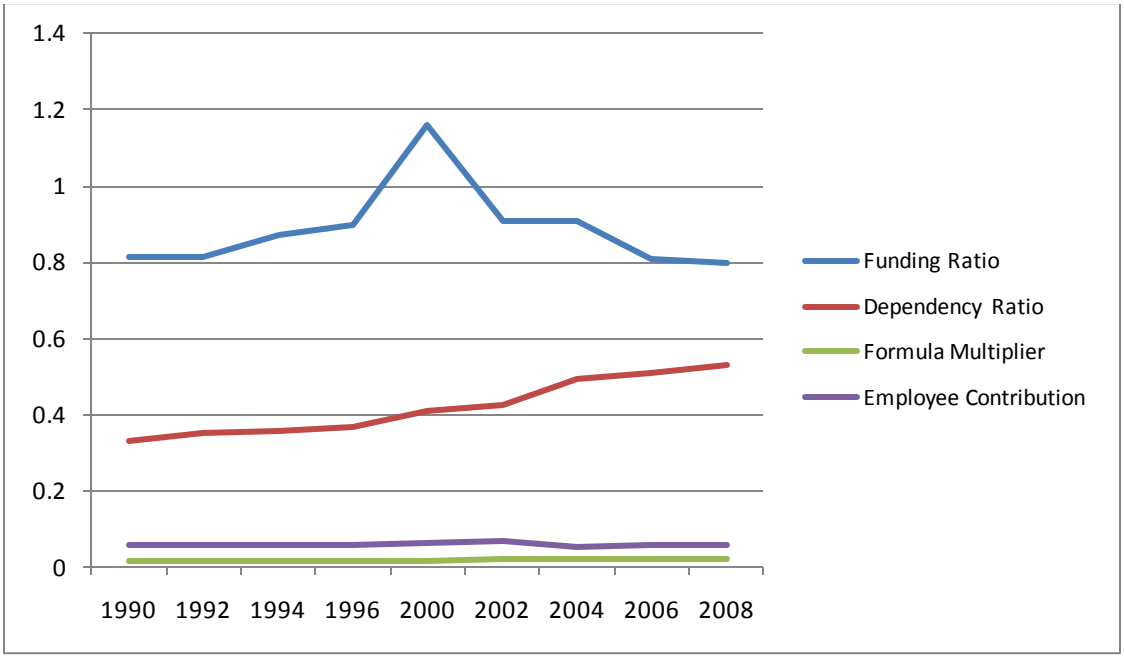


Figure 1: Pension Funding Over Time



Generated from the sample

Figure 2: The Development of the Variables from 1990 to 2008

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