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*Protecting underfunded pensions: the role of guarantee funds**

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Abstract

Employer-related pensions are a common and extremely important component of the compensation paid to workers in both the public and private sectors of developed economies. Many private pensions are insufficiently funded, exposing workers to the risk of a loss should their employer cease operations and not be available to meet pension obligations.

In this paper we study the role of guarantee funds as providers of insurance to workers against the failure of firms with underfunded defined benefit pension plans. Employing a model that predicts pension underfunding, we consider first how private guarantee funds might operate and then explore some potential advantages of public funds.

Overall, we do find that both public and private funds provide insurance benefits. However, private guarantee funds requiring *ex ante* premia payments may be infeasible in the presence of capital market imperfections, and funds which rely upon *ex post* contributions may suffer from strategic uncertainty. A public fund can overcome this coordination problem. However, a public fund, such as that administered by the US Pension Benefit Guaranty Corporation, may lead to: (i) greater underfunding of pensions, (ii) distortions in the market participation decisions of firms and (iii) the inclusion of excessively risky assets in the pension portfolio. In some cases, a guarantee fund is not welfare improving.

1 Introduction

In the United States, the underfunding of private sector pensions insured by the Pension Benefit Guarantee Corporation (PBGC) presents dangers not unlike those witnessed in the savings and loan sector in the 1980s. This has many experts concerned: the failure of an underfunded plan exposes both workers, to the extent

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the insurance is less than full, and taxpayers to potentially significant losses.[1] A recent discussion by Lawrence White (1993) of the underfunding by General Motors highlights some fears:

> The Federal Pension Benefit Guaranty Corporation, which pays off pensions up to a specified maximum if a fund goes bankrupt, has grounds to be nervous. Though companies pony up premiums for the coverage, the premiums are not properly scaled to compensate the agency for risk. Ultimately, taxpayers might have to absorb the Federal losses in a kind of saving-and-loan flimflam.

Recognizing the importance of pensions in financial portfolios and the very large contingent public liability through the PBGC, this paper studies the role and effects of pension guarantee funds. Our focus is on defined benefit pension funds that do not currently have sufficient funds to meet their expected obligations. These 'underfunded plans' expose workers to the risk that their pension promises will not be paid in the event the employer goes out of business. As indicated, the underfunding of defined benefit pensions can be substantial, leaving both employees and guarantee funds such as the PBGC exposed to considerable risk.

In this paper we ask how the risk associated with underfunded defined benefit pensions should be allocated across workers, firms and the government. To study this question, we specify a model in which the underfunding of pensions is due to capital market imperfections.[2] We consider first how *private* guarantee funds might operate and then explore some potential advantages of *public* funds. We find that private guarantee funds requiring *ex ante* premia payments may be infeasible in the presence of capital market imperfections and that funds which rely upon *ex post* contributions may suffer from strategic uncertainty. Hence private funds are unable to support the first-best allocation in which workers have full insurance and firms exit only when it is efficient for them to do so. While public funds can prevent coordination problems, they too cannot support the first-best outcome.

Finally, we explore the effects and efficiency of public funds like the PBGC, characterizing some of the distortions created by the presence of this type of guarantee fund. In particular, we find that guarantee funds may promote underfunding instead of reducing it. Further, these funds may distort compensation profiles and create incentives for the inclusion of overly risky assets in a pension portfolio. As a result, even public guarantee funds will not necessarily increase the welfare of plan participants.

2 Background

Employer-related pensions have become a common and extremely important component of the compensation paid to workers in both the public and private sectors

[1] See, for example, Weaver (1997) and the other studies cited therein.

[2] The model is a simplied version of that explored in Cooper and Ross (2002). The fact that pension characteristics and financial variables are linked is supported by empirical evidence cited in that earlier paper. Here we are interested in exploring the implications of guarantee funds given the imperfections in capital markets. Our model is not an incentive-based theory of pensions. Lazear (1981) motivates the existence of pensions as a device to elicit worker effort. Ippolito (1985a) takes this a step further and argues that underfunding arises to avoid *ex post* hold-up problems between unions and firms (see also Ippolito, 1986). These incentive theories do not provide any basis for pension guarantee funds as long as the contract between the firm and the union is privately efficient. Thus we focus on underfunding which reflects frictions in capital markets and thereby provides some argument for guarantee funds.

of many developed economies. For example, in the United States, approximately 43 million workers receive pensions insured by the Pension Benefit Guarantee Corporation.[3] Funds financing US pensions hold a significant and growing amount of wealth: the value of pension assets as a fraction of national wealth has grown dramatically over the last 50 years. Data from Schieber and Shoven (1997: 3) suggest that this fraction had risen from about 2% in 1950 to 24% in 1993. Under some proposed reforms of the social security system in the USA, private pensions may become even more important. Employer-sponsored pensions are prominent in many other countries as well. For example, in Canada, 43.4% of workers had some type of employer-sponsored pension in 1995.[4] Hannah (1992: 21) reports that employer-sponsored pensions have grown 'massively' in most OECD countries through the twentieth century.

Typically, pension funds collect contributions from employers and workers and are managed as a trust, independently from the employing firm. When a fund has sufficient assets to meet its projected obligations to retired workers, it is said to be 'fully funded'. There are two basic kinds of pension plans. With 'defined contribution' pension plans, the contributions to be made by employer and/or employee are dictated by the plan, while the payments to retirees are determined by the return earned on the invested funds. These are fully funded, almost by definition. In contrast, 'defined benefit' plans promise workers a specific benefit on retirement and the employer must make sure that there are sufficient funds in the pension plan to honor those promises. These funds may in fact be underfunded, exposing workers to losses in the event their firm goes bankrupt.[5]

Historically, the desire to protect workers from potentially significant losses due to the failure of their employer to honor pension obligations has produced a number of private and public responses. For example, several aspects of private pensions are regulated by pension legislation in many jurisdictions, including vesting provisions, acceptable fund investments and the level of funding.[6]

Concern about the exposure of workers with underfunded defined benefit pensions in the United States led to the passage of the Employee Retirement Income Security Act (ERISA) in 1974 which, among other things, created a government-run and supported guarantee fund and the organization to manage it, the Pension Benefit Guaranty Corporation (PBGC). Other such guarantee funds now exist in the Canadian province of Ontario (created in 1980), as well as in Sweden (1960), Finland (1962, partly privatized in 1994), Germany (1974), Chile (1981), Switzerland (1985) and Japan (1989).[7] These funds are somewhat controversial, as they can represent

[3] PBGC Web page: http://pbgc.gov/mission.htp. Since the Pension Benefit Guarantee Corporation does not insure all pensions this understates the fraction of workers with some type of pension. See the Department of the Treasury (1974, 1976) studies for data on pensions in the pre ERISA (i.e. pre-1974) era.

[4] Canadian data from Statistics Canada (1996: 7).

[5] Official US data on pension funding levels consider a pension plan to be underfunded if it does not contain sufficient resources to honor all obligations if the plan were to be immediately terminated.

[6] See, e.g., Altman (1992).

[7] See Smalhout (1996, chapter 5) and Pesando (1996). There is also discussion of other countries in Bodie *et al.* (1996).

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enormous contingent liabilities for taxpayers that may not have been adequately provided for by the premia paid.[8]

The PBGC has a couple of prominent characteristics which will feature prominently in the analysis to follow. The PBGC:

(*i*) *Stipulates a maximal level of pension insurance*
For example, in the single employer plan for plans with a 2000 termination date the maximum guarantee is $38,659.08 annually for a single life annuity beginning at age 65.[9] In addition, some types of benefits are not guaranteed. These include health and welfare benefits, severance benefits, lump-sum death benefits and disability benefits when death or disability occurs after plan termination.

(*ii*) *Relies on* ex ante *premia*
All single-employer pension plans pay a basic flat-rate premium of $19 (in 2000) per participant per year. Underfunded pension plans pay an additional variable-rate charge of $9 per $1,000 of unfunded vested benefits.[10]

(*iii*) *Pressures firms to fund pensions as fully as possible*
Under ERISA firms are required to address pension underfunding, though they are given some time period over which to do this. Changing market conditions and individual firm circumstances (e.g. enriched pension plans) can make this a moving target which some firms appear unlikely ever to hit. The Retirement Protection Act of 1994 contained provisions to accelerate funding for underfunded plans; gave the PBGC greater powers to enforce minimum funding levels; introduced requirements that firms with significantly underfunded plans provide the PBGC with detailed financial information and advanced notice of significant corporate transactions; and increased premia for underfunded plans. Premia are not related to other firm characteristics, such as industry or the probability of firm bankruptcy.

Despite pressure by the PBGC, the extent of underfunding is clearly significant. In 1996 underfunded pension liabilities in the United States amounted to over $83 billion in PBGC-insured single-employer plans. By 1998 a rising stock market apparently lowered the level of underfunding to $49 billion. It increased in 1999 and then with strong markets plunged to $6 billion in 2000. More recently, falling stock values have significantly increased the level of underfunding.[11] There are currently about

[8] Smalhout (1996) is a vigorous critic of the PBGC, for example. He also describes the collapse of the Finish fund in the early 1990s (at 214–223). Similar concerns in Ontario are likely the reason that fund is being effectively eliminated by inflation as its maximum benefits are unchanged from the relatively low levels set back in 1980.

[9] The limit is adjusted annually based upon changes in the Social Security contribution and benefit base. In addition, for those who retire before age 65 the maximum is adjusted downward. For example, at age 55 the maximum guarantee is $17,396.64 yearly.

[10] The premium was first set at a flat rate of $1 per participant in 1974. The current rate for fully funded plans was set by Congress in 1991. Adding additional premia for underfunded plans began in 1987. While the addition of the variable-rate charge has helped make premia better reflect the actual expected liabilities, it remains the case that the plans that represent 80 % of the underfunding contribute only 50 % of the premium revenue. For the smaller multi-employer program, the current premium is $2.60 per participant per year. See 'FACTS' on www.pbgc.gov.

[11] Pension Benefit Guarantee Corporation (2003, Table S-23). In 2000, there was another $22.2 billion in underfunding in the PBGC- insured multi-employer plans (2003, Table M-8).

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16 million US workers in underfunded pension plans, although not all firms and industries are equally responsible for this shortfall: out of a total of about 49,000 insured single-employer plans in 1996, the 50 plans with the highest amounts of underfunding were responsible for 36.5% of total underfunding.[12] The PBGC closely monitors a group of about 500 companies which each sponsor pension plans underfunded by at least $5 million. While these firms represent only about 1% of all insured plans, they are responsible for over 80% of the underfunding.[13]

Measuring the scale of the underfunding 'problem' is not without controversy as it requires a complicated determination of the discounted present value of expected obligations to workers and the income to finance these flows. From this viewpoint, underfunding does not necessarily expose workers to any risk. Consider a firm with an unfunded pension but future profit prospects which are so good that even in the worst of all possible states it can meet its pension obligations out of future revenues. In this case, which is examined in more detail below, the level of the pension fund is irrelevant to the worker.[14] Thus even though the plan is underfunded according to the PBGC, neither the worker nor the guarantee fund is actually exposed to any risk.

In contrast, Ippolito (1985b) argues that official statistics understate the extent of underfunding. If a worker is currently earning a salary of $40,000, the legal obligations of the fund, if it was terminated today, would be based on the regular pension formula evaluated with a terminal salary of $40,000. However, if the plan is not terminated today and the worker and firm expect the worker to retire with a salary of $50,000, the real obligations incurred this year will be determined by the formula evaluated at a salary of $50,000. In short, having enough money in the fund to meet obligations were you to wind up the fund today is not the same thing as having enough to meet the truly anticipated future demands on the fund.

3 Optimal contracts and the basis of underfunding

Any discussion of remedies for underfunding must explain why there is underfunding in the first place. Cooper and Ross (2002) argue that inadequate capital is a source of pension plan underfunding.[15] Instead of reproducing those results, we simply study the optimal contracting problem with an imposed borrowing restriction as a vehicle for studying the role of guarantee funds. This section discusses the contracting problem and provides conditions for underfunding.

[12] See FACTS: Early Warning System at www.pbgc.gov.

[13] See FACTS: Early Warning System at www.pbgc.gov. Another high-profile example has recently appeared. The company that sponsors two Trans World Airlines (TWA) pension plans recently notified the PBGC that it intends to terminate the plans, which cover 36,500 current and former employees, and which are underfunded by more than $700 million. See TWA Information Alert at www.pbgc.gov/twa/twa_alert.htm.

[14] We are grateful to Zvi Eckstein for discussions on this point.

[15] Cooper and Ross (2002) study a model in which the firm contracts with both workers and an intermediary. There is a moral hazard problem which, in the optimal contracts, limits the ability of the firm to borrow. As a consequence, the pension is underfunded. Cooper and Ross (2002) also discuss evidence linking investment behavior (both physical investment and in pension funds) to the financial status of a firm. In some cases, the literature does point to size as a factor in credit market frictions.

3.1 Basic model

In this model, a firm contracts with a single worker for two periods.[16] The worker supplies labor services to the firm in period 1 (youth) and is retired in period 2 (old age). The contract is between the worker and the firm is denoted by $\delta=(w^y, w^o)$, where w^y is the wage paid in period 1 and w^o is the promised retirement pay in period 2. We assume that workers have no private means of savings to highlight the important role of savings through private pension plans.[17] Workers preferences over consumption in each period, c^i for $i=y,o$, are represented by $U(c^i)$. Assume that $U(c^i)$ is strictly increasing, strictly concave and that $U'(0)=\infty$. The worker's lifetime utility is given by $U(c^y)+U(c^o)$.

Let u^* denote the level of lifetime utility the worker receives if he does not contract with the firm. Finally, let w^* solve $2U(w^*)=u^*$. This represents a time and state independent wage that yields the worker a utility flow of u^*. Given the worker's risk aversion, payments of w^* in both periods will represent the least costly way to guarantee the worker a level of utility u^*.

The firm's goal is to maximize the present discounted value of its profits, using a discount factor of β. There is a riskless asset in the economy that has a gross return of R.[18] We assume that $\beta=R=1$ so that the firm, like the worker, is indifferent about the timing of its income flows given that it can buy and sell this riskless asset.[19]

The firm begins period one with financial capital (K), the (young) worker provides labor and is paid a wage w^y. There are no other factors of production and output is created with a lag. The value of the output created by this labor in the second period varies with exogenous market conditions.[20] Let the value of the output produced be denoted by A which ranges from 0 to $\bar{A}$ with a distribution $F(A)$. This distribution is not influenced by actions of either the worker or the firm: i.e. there are no moral hazard considerations in the model.[21]

16 Equivalently, these negotiations could be between a firm and a union made up of identical workers in which the union's objective is to maximize the utility of its typical member.

17 This is obviously a very extreme assumption. It is meant to provide a basis for pensions: if workers could costlessly engage in the same asset market trades, the role for pensions would be greatly reduced. Support for this assumption comes from work that shows that there are economies of scale in pension fund management such that pooled funds can be more efficiently managed than individual funds. See, for example, Gustman *et al.* (1994: 422) and the references cited therein.

18 The effects of stochastic returns are discussed in a subsequent section where we explore some of the moral hazard implications of guarantee funds.

19 The restriction that $\beta R=1$ implies that the firm is indifferent with respect to the timing of flows. The assumption that $\beta=R=1$ is just a normalization.

20 We have adopted this structure as the simplest that allows us to get at the heart of the problem we care about here. We need a structure that highlights the fact that, in a defined benefit pension structure, underfunding necessarily implies that the retirement compensation of a worker depends on the future profitability of the firm. That is then the set-up for our analysis of guarantee funds. Our production process provides this intertemporal dependence in a simple, tractable way. We could, at some cost in terms of complexity, generalize the process by, for example, allowing more periods (perhaps even with overlapping generations of workers) or allowing some immediate payoff to worker effort; and we can even think of the second period shock to profitability as coming from a source other than the realized productivity of labor effort. All of these models would give us underfunding that exposes workers to the risk of loss if their employer ceases operations which is what we need to do our study of the role and effects of guarantee funds.

21 In contrast, Lazear (1981) argues that moral hazard considerations are important for understanding pensions. We do not dispute this point but contend that moral hazard *per se* does not lead to underfunding, just upward-sloping wage profiles with pensions providing incentives.

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At the start of the second period, the firm learns the realized value of the profitability shock (A) and must decide whether or not to continue operations. We assume that continuation of the firm requires the commitment of entrepreneurial time worth e.[22] This gives the firm a bankruptcy or exit option which generates one of the key distortions of pension funding in our model since this decision will reflect outstanding pension obligations as well as the current level of pension funding. Intuitively, a firm with large pension obligations and relatively low levels of funding will opt out of a market even when production is efficient. We show that by influencing funding levels, guarantee funds can affect the probability of such inefficient exit.[23]

If the firm does elect to continue its operations, we assume it must honor its outstanding promise of w^o to the (old) worker in the second period. Funding for this payment comes from the flow of output and a pension fund. The firm creates a pension fund (P) in period one by setting aside monies that can only be used to pay for the worker's pension. These funds are invested in riskless but zero return assets.[24] These funds form a commitment on the part of the firm: by assumption, they cannot be used for other purposes unless workers have received their entire promised pension benefits.

In addition to their pensions, workers have a claim on the output of the firm in the second period so that their second period consumption is not completely determined by P. In our model, pensions thus take the form of defined benefits rather than simply defined contributions. Other funds of the firm ($K-P$) not assigned to the pension fund cannot be claimed by older workers in the event there is a shortfall in the second period.

We make two assumptions about the preferences and technology. The first assumption guarantees that the project is profitable *ex ante* if the worker is paid w^* each period.

Assumption 1. $E(A-e|A>e)>2w^*$.

The second assumption implies that the worker and firm will contract even if the worker is compensated only in the event the firm continues operation in period 2. As we shall see, this assumption allows us to focus on the efficiency of the firm's continuation decision and not the entry decision.

Assumption 2. *There exists a wage, w, such that* $(1-F(w+e))U(w)=u^*$.

[22] In fact, the magnitude of e is not critical: the fact that the firm makes a decision to continue or not is the important element of the model.

[23] Our problem is similar to others in the insurance literature where it has been appreciated for some time that a bankruptcy or exit option (with the associated limited liability) will limit an insured's interest in acquiring full insurance for harms it might do to others. This point was made by Calabresi (1970: 58) with respect to a potential injurer's incentive to fully insure himself for accidents he might cause. The result is that exit occurs too frequently, in order to avoid certain obligations. Huberman, Mayers and Smith (1983) and Keeton and Kwerel (1984) were among the first to model this formally. See also Shavell (1987: 240–243). A more general treatment of the effect of limited liability on principal-agent contracts can be found in Sappington (1983).

[24] Thus the rate of return on the pension is equal to that from the riskless asset. Cooper and Ross (2002) explore the distortions created when the return on pension fund investments is below R, which could be the case if there are regulatory constraints on permissible pension fund investments.

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3.2 Optimal contract

We study the following optimization problem

$$V^n(K) = \max_{(w^y, w^o, P)} K - P - w^y + \int_{w^o + e - P}^{\bar{A}} (A + P - w^o - e) dF(A)$$
$$s.t. \tag{1}$$
$$U(w^y) + F(w^o + e - P)U(P) + [1 - F(w^o + e - P)]U(w^o) = u^*$$
$$K \geqslant P + w^y, \quad P \geqslant 0$$

The firm's profits will come from the resources $K - P - w^y$ left over in the first period and $(A + P - w^o - e)$ in the second period as long as the realized value of A is large enough that it is profitable to continue. The constraint that the firm is unable to borrow is imposed by requiring that $P + w^y \leqslant K$.

The firm will continue to operate if and only if

$$A + P > e + w^o \tag{2}$$

A firm that continues must provide workers their promised pension benefits (w^o).[25] It will not have an incentive to continue unless its sources of funds exceed its obligations: $A + P > w^o + e$. So, in (1), the firm receives $A + P - w^o - e$ in the states in which it continues operation. For low values of A, the firm will cease operation and earn zero profit while the worker receives a pension.

In (1), the worker's participation constraint reflects the uncertainty over pension payments in the second period. That is, the worker receives the full pension payment of w^o if and only if the firm, after learning the realization of A, remains in business. Otherwise, the worker receives the pension funds (P). Thus we are assuming that the firm can protect any capital not invested in the pension from the workers in the second period: K is the pool of capital available to this firm, but what is actually used is only $P + w^y$. Any part of K not needed for this is made available for other uses outside this particular firm – and beyond the reach of its employees.

In this formulation of (1), we have assumed that the pension will not be overfunded. That is, the restriction that P does not exceed w^o is used in the statement of the problem. We argue below that there is no incentive in our environment for overfunding since this provides no additional insurance benefits to workers.

3.3 Underfunding

We now study conditions under which the solution to (1) implies underfunding of a pension. The key, given the presence of borrowing restrictions, is the level of internal funding. We start with the case of a firm with large K to establish a benchmark.

The central issue in this contracting problem is the provision of second period consumption for workers. As is usual in optimal labor contracting problems, the firm acts as an insurer, a banker and a producer.[26] Given that the firm is risk neutral and

[25] We could relax this by assuming that, if $A + P - e \leqslant w^o$, the firm would be permitted to continue if it pays its workers all it had (i.e. $A + P$), but this can never be profitable for the firm.

[26] This view of contracting started with Azariadis (1975).

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has the same discount factor as the worker, the cost-minimizing contract will completely insure workers and smooth their consumption over time by paying the worker w^* in each period. The feasibility of this contract depends on the level of K.

Proposition 1. *If $K \geqslant 2w^*$, $w^y = w^o = w^* = P$ and the exit decision will be efficient.*[27]

Throughout we term this outcome the *first-best allocation*. It entails a number of characteristics that correspond to the solution of a planner's problem: the optimal allocation of risk, an efficient continuation decision and the efficient choice to initiate the project.

Proposition 1 shows that if the firm has sufficient financial capital ($K \geqslant 2w^*$) and there are no distortions in capital markets so that the return on pensions (assumed to be equal to 1) is the same as the return on alternative investments ($R=1$), the firm will fully insure the worker's consumption in both periods of life. In equilibrium, there is no underfunding of pensions even in the absence of tax incentives to fund pensions.

As for the continuation decision, recall that the firm will remain in operation, after observing A, if and only if $A+P-w^o-e>0$. With a fully funded pension, this inequality holds if and only if $A>e$, the condition for efficient continuation.

Finally, from Assumption 1, we know that the project is *ex ante* profitable when workers are paid w^* in each period. That is, $V^n(K)>0$ for $K>2w^*$ where $V^n(K)$ is the value of the firm from (1).

In contrast, if a firm has insufficient financial capital (i.e. a low K), then the first-best contract characterized in Proposition 1 will not be offered and pensions will be underfunded. One consequence of this is that the wage profile will not be flat. A second consequence is that a firm with an underfunded pension faces an additional cost of continuation (given by w^o-P) and thus will choose to exit when it is socially efficient to continue operating. Formally,

Proposition 2. *If $K<2w^*$, then $w^o>w^y>P$ and the firm will exit for some realizations of A such that continued operation is efficient.*

The result that the wage profile is upward sloping reflects the low value of K.[28] Given this capital inadequacy, the firm underfunds the worker's pension, relying on high realizations of A to pay pension obligations.

In addition to exposing workers to risk, the underfunded pension implies that there are some states in which the firm exits even though $A>e$ as the outstanding obligation acts as an additional cost of continuation. This result points to an important theme: the continuation decision is influenced by the extent to which the pension is funded.

There is potentially another type of inefficiency associated with a low level of K: projects that are economic in the sense of Assumption 1 may not be initiated. Formally, it may be with K sufficiently low that $V^n(K)$, the value of the optimal contract in (1) to the firm, may be negative. If so, there is an additional distortion created by the low capitalization of the firm. While interesting in its own right, our focus here is

27 The proof of this and subsequent propositions are in the appendix.

28 As discussed in Cooper and Ross (2002), even if borrowing is possible but hampered by moral hazard considerations, underfunding will still arise.

on the inefficiencies created by the continuation decision. With this in mind, we use Assumption 2 to rule out this second kind of inefficiency: given this assumption, a firm with $K=0$ can attract a worker so that $V^n(0)$ is clearly non-negative as the firm will only continue when it is profitable to do so. Since $V^n(K)$ is increasing in K, $V^n(0) \geqslant 0$ implies that the firm will operate the project for all K.

Finally, we return to the assumption made in the statement of the contracting problem in (1) that pensions were not overfunded. Allowing the overfunding of pensions would not change the results in Proposition 1. Clearly a firm with a high value of K may have enough resources to overfund a pension but since it can already offer the first-best contract, there are no gains to overfunding. Allowing overfunding if the firm has a low value of K will also not change Proposition 2. In this case, the shortage of K implies that the wage profile is upward sloping and pensions are underfunded. Allowing for overfunding will certainly not alleviate the inefficiencies created by the shortage of capital.

Note that the problem associated with defined benefit plans highlighted in Proposition 2 will not disappear if the firm was instead to offer a defined contribution plan. In our model, defined benefit plans will dominate defined contribution plans for firms with low levels of K, precisely because they permit underfunding. To see this, consider defined contributions plans in our model by adding the constraint that $P=w^o$ to (1): that is, all pensions must be provided for by payments to a pension fund during the first period. Two things become immediately clear about such pensions. First, as there is no *ex post* payment to workers (beyond those provided for by the pension fund), defined contribution plans will never distort the continuation decision. Second, a firm with $K<2w^*$ will not be able to operate with such a plan. For firms with $K \geqslant 2w^*$, the two types of plans will be essentially equivalent as both support the first-best contract. Thus, despite the inefficiencies it can generate, the defined benefit structure dominates when it helps firms deal with capital market imperfections.

In sum, a firm with sufficiently large initial capitalization will offer the first-best contract. This entails a fully funded pension, efficient risk sharing and efficient decisions on continuation. In contrast, a firm with small K will underfund its pension, offer an upward-sloping wage profile and will exit too often relative to the socially efficient decision. Given that private pensions may not be adequately funded in the presence of capital market restrictions, it is natural to turn to alternative means of insuring workers' pension benefits. Thus, using this model of underfunded pensions, we turn to our analysis of guarantee funds.

4 Private guarantee funds

In these sections we investigate whether guarantee funds can support the first-best allocation. For the analysis, guarantee funds are characterized by three features: (i) whether they are private or public, (ii) the details of their contract with the firms and (iii) the timing of their funding relative to the resolution of uncertainty.[29] We discuss these in turn.

[29] For a more general discussion of the benefits of guarantee funds and the problems they can create, see Cooper and Ross (1999).

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We distinguish between private funds and the public funds described in the next section with reference to the ability of the latter to draw on additional resources (i.e. taxes) if needed to cover obligations. The question of whether or not participation is voluntary is a separate question – even under a private insurance system, the government may compel pension plans to belong to some guarantee fund. For the purposes of the analysis that follows we will assume that all firms have decided to participate in the guarantee fund (perhaps because they are required to by law), though this is not an innocent assumption. As we shall see, participation in the fund can make some firms worse off; a point to which we will return below. In our approach, the only way for firms to avoid their obligations to workers and/or the fund is by shutting down.

While this paper is partly motivated as a study of public guarantee funds, such as the PBGC, private guarantee funds existed prior to the PBGC. It has been argued that problems with those private plans lead to the creation of the PBGC.[30] In addition, a number of scholars have recommended partial or complete privatization of pension benefit insurance.[31] For these reasons, we believe it is important to understand how well private funds might perform relative to public funds. In this section we focus on private funds and turn to a rationale and discussion of public funding in the section that follows.

Considering the details of the contract between the private guarantee fund and the firms, we assume that the realization of the profitability shock, A, is private information. This implies that the guarantee fund cannot enforce a state contingent continuation policy by the firm. As a result, firms will take the terms of the guarantee fund as given and determine unilaterally whether or not to continue operation. We do allow for the level of guaranteed pension benefits to be stipulated in the contract between the firm and the guarantee fund. This minimizes moral hazard problems that may arise if firms make excessive promises to their workers which will be fulfilled by the guarantee fund. Finally, we do not allow the fund to stipulate a minimal level of pension funding, nor can it link the premium charged to the firm's policies *vis-à-vis* its workers. We return to these restrictions later and explore the robustness of our results.

On the issue of timing, we consider a fund with both *ex ante* and *ex post* contributions. That is, firms make *ex ante* payments to the fund at the start of time (period 1) and those that remain in business make *ex post* contributions to support workers whose employers failed in period 2. As we shall see, an important element in the model is that the fraction of firms failing in period 2 is endogenous, since their *ex post* contribution depends inversely on the number of firms that remain in operation.

This guarantee fund shares many of the key characteristics of the PBGC, outlined earlier. However, our fund is more general in that we are considering both *ex ante* and *ex post* funding. It should also be clear that the powers we have chosen to give to the fund will influence what the fund can accomplish. Specifically, we do not tie fund premia to firm history or funding levels, we do not compel firms to fully fund pensions

[30] See, e.g., the Treasury Department studies (1974, 1976).
[31] See Weaver (1997) and the references cited therein.

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and we do not allow the fund to prevent a firm from shutting down. We have chosen an abstract, tractable formulation of the guarantee fund in order to help us better understand the interactions between guarantee funds and the optimal contract. We will discuss some of the implications of relaxing some of the more restrictive assumptions.

4.1 Optimal contract

The contracting problem has two aspects. First there is the contract between a firm and its worker. As before this contract specifies a payment to workers when young (w^y), a promised payment when old (w^o) and a private pension (P). Second there is a contract between a set of firms and the guarantee fund that specifies an *ex ante* payment to the fund (τ), an *ex post* assessment levied only on firms that remain in business (z) and a cap on the payment to workers of failed firms given by $\overline{W}^o$. In general, the firms that join together to create a guarantee fund need not have any other connections with one another, though in practice these funds tend to be organized by firms in a common industry.

Here we interpret $\overline{W}^o$ as a commitment by the fund to guarantee that retired workers at failed firms receive their promised retirement consumption up to this level from two sources: the firm's pension plan and payments from the guarantee fund. Thus $\overline{W}^o$ represents a cap on the compensation that the guarantee fund will pay workers of failed firms.[32] Then we can write $W^o = \min(w^o, \max(P, \overline{W}^o))$ as the actual level of compensation a worker will receive in the second period if the firm exits. In a case in which promised second period compensation exceeds both the cap and the amount invested in the pension fund, the worker will only get the larger of what is in the fund and the capped benefits from the fund.

Given the terms of the private guarantee fund (τ, z, $\overline{W}^o$), the firm solves

$$\begin{aligned} V^f(K) = \max_{(w^y, w^o, P)} K - P - w^y - \tau + \int_{w^o+e-P+z}^{\bar{A}} (A+P-w^o-e-z)\,dF(A) \\ s.t. \\ U(w^y) + F(w^o+e-P+z)U(W^o) + [1-F(w^o+e-P+z)]U(w^o) = u^* \\ K \geqslant P + w^y, \quad P \geqslant 0 \end{aligned} \tag{3}$$

The guarantee fund takes resources away from the firm *ex ante* as a premium is paid. Further, the *ex post* assessment of z extracts additional resources if and only if the firm continues. So, not surprisingly, the magnitude of the *ex post* assessment will influence the continuation decision of the firm. Of course there is a constraint, imposed below, that the guarantee fund breaks even.[33]

From the worker's perspective, there are only two possible states *ex post*. Either the firm meets its promise of w^o, which occurs with probability $(1 - F(w^o + e - P + z))$,

[32] Such caps exist in practice. See the discussion of the PBGC in Section 2 above.

[33] While we will continue to assume that the borrowing constraint is exogenous here, we acknowledge that the presence of the guarantee fund could lead lenders to be more or less willing to loan funds to these firms. To the extent that the fund permits firms to offer more efficient wage profiles, the firms will be more profitable and hence perhaps better credit risks. However, when guarantee funds induce firms to underfund pensions to a greater extent (and perhaps also charge *ex post* premia to continuing firms), they increase the range of states in which the firm chooses not to continue. This would discourage lenders.

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or ceases operation after learning the value of A. In this case, the worker's total consumption is the maximum of $\overline{W}^o$ (as guaranteed by the fund) and P, the pension fund left by the firm as long as this maximum exceeds w^o. In these states, the firm receives a payoff of 0 in the second period. Note from (3) that the *ex post* assessment influences the continuation decision of the firm.

4.2 Supporting the first-best allocation

Our objective is to determine if the first-best allocation can be supported by a private guarantee fund. Put differently, does there exist a fund, characterized by (τ, z, $\overline{W}^o$), such that the workers receive complete insurance and the continuation decision of the firm is efficient?

To support the first-best allocation, $\overline{W}^o$ must be set at w^*, the first-best level of consumption for retired workers. Further the fund must break even implying that the *ex post* assessment per firm (worker) is given by

$$z=\frac{(1-\alpha)(w^*-P)-\tau}{\alpha} \tag{4}$$

where τ is the *ex ante* assessment and (w^*-P) is the level of compensation paid by the fund. In this expression, the probability of continuing is α, an equilibrium variable detailed below.

Our main result is negative: the fund is unable to support the first-best allocation.

Proposition 3. *In the presence of a private guarantee fund with* $\overline{W}^o=w^*$, *if* $K\geqslant w^*+\tau$ *the firm will set* $P=0$ *and* $w^y=w^o=w^*$. *Further, the firm will exit when continuation is efficient.*

One of the more important moral hazard implications of guarantee funds emerges: firms will not have an incentive to finance their own pensions. Instead, they will rely entirely on the guarantee fund to support their workers. This makes sense: given that $\overline{W}^o=w^*=W^o=w^o$, in effect, resources placed into a pension do not flow to workers; rather they only subsidize the private guarantee fund. Thus, guarantee funds imply underfunded pensions. Note that this result holds even for firms with values of K high enough to fully fund their own pensions. With no funding of the pensions, the relationship between the *ex ante* and *ex post* charges becomes

$$z=\frac{(1-\alpha)w^*-\tau}{\alpha} \tag{4'}$$

The fund does reach the goal of supporting the first-best levels of consumption for workers as long as K is large enough. Thus, relative to Proposition 1, the first-best consumption profiles can be supplied by firms with lower levels of initial capital as long as the *ex ante* payment, τ, is less than w^*.

Further, note that the exit decision is distorted: even if the *ex post* assessment is 0, the firm continues if and only if $A>e+w^*$. In contrast, efficiency dictates continuation if and only if $A>e$, as in Proposition 1. The private guarantee fund implies inefficient exit because, with $P=0$, a firm that continues will have to compensate retired workers. It can avoid these payments through exit, however. In contrast, in

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the absence of the guarantee fund, the firm will establish its own pension (assuming K is large enough) and thus exit will be efficient as these payments to retired workers cannot be avoided.

Of course, the motivation for the guarantee fund stems from a desire to insure workers at low K firms. For those firms we find:

Proposition 4. *In the presence of a private guarantee fund with* $\overline{W}^o = w^*$, *if* $K < w^* + \tau$ *the firm will set* $w^y = K - \tau - P$, $w^o > w^* > w^y$ *and* $w^o > P$. *Further, the firm will exit when continuation is efficient.*

In this case, the upward-sloping wage profile from Proposition 2 reappears in the presence of a guarantee fund. Further, the pension is underfunded and consequently the firm will exit inefficiently.

Overall, the outcome under a guarantee fund will not be efficient. The obvious solution, of course, is to force $P = w^*$. However, forcing a high level of pension funding (even if feasible) is only possible for firms with $K \geqslant 2w^*$. Of course, it is these firms (from Proposition 1) that provide the first-best allocation without a fund. Thus, forcing $P = w^*$ will not support the first-best as long as there are some firms with $K < 2w^*$.

Alternatively, one might consider other types of contracts between the guarantee fund and the firm to overcome the distortion in the continuation decision. Given that the profitability shock is not publicly observable, it is not feasible for the fund to force continuation. Nonetheless, linking the *ex ante* tax directly to the level of funding will induce higher levels of P, and thus more efficient continuation decisions. Further, tax incentives, as in place in the US, might induce greater funding.

Still, these more complex contracts will be unable to support the first-best allocation of risk. Given the limited borrowing ability of firms, unless $K > 2w^*$, these mechanisms will be unable to induce the full funding of pensions. Thus a version of Proposition 4 will hold: the continuation decision will be distorted as firms with $K < 2w^*$ simply do not have enough resources to pay workers w^* in both periods and fully fund their pension.

Put differently, the problem with underfunding that we have highlighted reflects imperfections in capital markets that guarantee funds are unable to overcome despite the insurance benefits of these funds. Though guarantee funds might devise incentives for positive levels of pensions, the first-best allocation is not attainable.

4.3 Ex ante vs. *Ex post funds*

Propositions 3 and 4 did not require a precise statement of how the resources for the guarantee fund were raised. In fact, there are some important elements in the choice between *ex ante* and *ex post* payments to the fund. We illustrate these issues assuming $K \geqslant w^* + \tau$ as in Proposition 3.[34]

From the proof of Proposition 3, it is evident that the compensation levels provided to the workers depend on $\overline{W}^o$, which has been set at w^* in the proposition, but not on the choice of (τ, z) as long as the borrowing constraint does not bind.

[34] As discussed below, our main result of this section, Proposition 5, will also hold for low values of K.

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However, the continuation decision is directly influenced by the level of the *ex post* assessment. In particular, a firm will continue to operate if and only if:

$$A > e + w^* + z - P \quad (5)$$

Clearly, increases in *ex post* assessments lead the firm to exit more frequently. Given that the absence of a pension fund implies inefficient exit to start with, a positive value for z exacerbates this distortion.

From this perspective, *ex post* assessments should be minimized and financing should be *ex ante*. However, in this case we have some interesting interactions between the financing of the guarantee fund and the borrowing constraint. At the extreme in which all assessments are *ex ante*, then $z = 0$ and

$$\tau = (1 - \alpha) w^* \quad (6)$$

Hence in this case, Proposition 3 characterizes the behavior of a firm with $K \geqslant w^*(2 - \alpha)$. Thus as long as there are some firms that continue ($\alpha > 0$), the critical level of K such that the first-best compensation can be provided is lower than in the absence of a fund.

Therefore, while *ex post* funds seem preferable as a way to avoid binding capital market restrictions, they lead to distorted continuation decisions. In contrast, *ex ante* funds are preferable when firms have enough capital to afford these premia.

There is an important element missing in this discussion: the equilibrium determination of the exit probability (α). In fact, we shall argue that this leads to some insights into a benefit of public relative to private funds and enriches the tradeoff between *ex ante* and *ex post* funding.

As noted above, *ex ante* payments may not be feasible for some firms so that *ex post* assessments may be needed. However, the resource constraint for the guarantee fund, given in (4′), indicates a strategic complementarity in the continuation decisions of firms.[35] As the fraction of firms that continue falls, the remaining firms must shoulder a larger burden of the *ex post* funding of the pension payments to bankrupt firms. This is effectively a tax increase for continuation which reduces the likelihood a given firm will remain in business.

More formally, the continuation probability α is a decreasing function of the *ex post* assessment z. Further, the *ex post* assessment is itself a decreasing function of α. Hence, the continuation probability of one firm is a increasing function of the continuation probability of the other firms.

In some cases, this strategic complementarity, can lead to multiple equilibria in the continuation decisions of firms when the guarantee fund has *ex post* assessments. To see this, consider the contracts stipulated in Proposition 3 with

$$\tau^* = (1 - \alpha^*) w^* \quad (7)$$

where $(1 - \alpha^*)$ is the exit probability assuming that there are no *ex post* assessments. This probability is given by

$$\alpha^* = 1 - F(e + w^* + z) \quad (8)$$

[35] Strategic complementarities are often created by the need to finance a fixed amount of expenditures, as discussed in Cooper (1999, Ch. 7).

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Then:

Proposition 5. *If $\overline{W}^o = w^*$, τ^* is given by (7) and (4) holds, then there exists an equilibrium in which* ex post *assessments are zero and another equilibrium where the guarantee fund is bankrupt.*

The logic here is similar to that in other coordination problems in which the gains to participating in an activity depends on the fraction of others participating in that activity. In the optimistic equilibrium, firms correctly assume that other firms will exit if and only if $A < e + w^*$ and there are no *ex post* assessments since τ^* covers the obligations of the realized fraction of firms who exit. In the shutdown equilibrium, the firms are pessimistic and think that others will exit. In this case their best response is to exit too since their obligations as the only active firm will be excessive.[36]

Of course, this analysis could be completed by introducing the probability of the shutdown equilibrium, modelled through sunspots, into the original contracting problem.[37] As stated, (4′) implicitly ignored the strategic uncertainty in the determination of *ex post* assessments. To the extent that the coordination failure reduces welfare, adding the strategic uncertainty will not overturn the main point of the proposition: guarantee funds will not support the first-best allocation.

The *ex post* coordination problem highlighted in the proposition is more than a theoretical possibility. For example, in 1996 the PBGC came to the rescue of a multi-employer pension fund in the men's suit industry. The pension fund had liabilities exceeding assets by about $250 million and without relief would have been forced to cut benefits paid to retired workers.

Interestingly, the *New York Times* (1996) reported that

> Federal officials said employers were withdrawing from the fund faster, increasing the burden on those that remained. The fund contributors has dwindled to 200 from 575 a decade ago.

Further, the same article quoted Labor Secretary Robert Reich as saying that under the government rescue plan:

> Workers will get the full pensions they earned, solvent employers will not be ruined by the pension obligations of the failed companies and taxpayers don't have to fear that they will be left holding the bag.

Consistent with our emphasis on pension troubles emanating from adverse economic conditions, it is noteworthy that this industry has certainly suffered over recent years. An interesting component of the agreement between the PBGC and the industry is that the cost of withdrawing from the new plan is 150% of a company's outstanding liabilities to the plan.[38]

[36] Clearly this interaction is present for any *ex post* fund and in this way our results hold for low values of K as in Proposition 4. In addition, given the complementarity induced by the *ex post* assessments there may be other equilibria with some but not all firms exiting due to the *ex post* obligations.

[37] This was the approach in the Cooper and Ross (1998) analysis of bank runs, for example.

[38] Multi-employer plans were also common prior to the introduction of the PBGC. Treasury (1976) is devoted to studying the success of these plans and in fact it does seem that these plans were, overall, more stable than single employer plans. The Treasury study does report that there were many mergers of plans. Perhaps this was the private sector response to instability of these plans. Unfortunately, we have no information on the nature of the contract between plan participants nor any costs that might have been imposed on those leaving a plan.

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5 Public guarantee funds

We now extend our analysis to consider public rather than private guarantee funds. The analysis above clearly applies to the case of a public guarantee fund, such as the PBGC, in which a fund continues to be characterized by $(\tau, z, \overline{W}^o)$. As before, firms take these terms as given and contract with their workers. Propositions 3 and 4 hold with a public fund. While underfunding was also a problem for poorly capitalized firms in the absence of the guarantee fund (recall Proposition 2), underfunding is now much more widespread as, from Proposition 3, it extends to firms with large values of K. Of course, this explains why the PBGC must pressure firms to more fully fund their pensions.[39] It is not the underfunding *per se* (this is effectively just a transfer) that is the problem but rather the distortion of the continuation decision that is the source of the inefficiency.

Importantly though, Proposition 5 may not apply: there need not be strategic uncertainty over public *ex post* funds. As in discussions of publicly provided deposit insurance, the government has access to resources from various forms of taxation that can be used to supplement the *ex ante* fund if needed. In this case, if the government can credibly commit to use these outside forms of taxation, then the equilibrium with positive *ex post* assessments from Propositions 3 and 4 will disappear. Effectively, the pessimism about the exit of other firms and thus the high tax burden on continuing firms is eliminated by the government's commitment to support the fund. Of course, in equilibrium the government is never called upon to actively supplement the *ex ante* contributions of the fund as long as they are sufficient to cover expected losses.

We now turn to additional properties of the allocation with guarantee funds. We do so assuming a public guarantee fund so that the coordination problem suggested by Proposition 5 is absent.

5.1 Welfare implications

Given that a guarantee fund will not support the first-best, does a guarantee fund increase welfare? Intuitively, there are two main effects of a guarantee fund. First, the fund provides insurance to workers with underfunded pensions. Our motivation for pension guarantee funds was based upon underfunding, which was itself a consequence of capital market imperfections. From this perspective, a guarantee fund can improve welfare by providing an insurance substitute for the inability to borrow enough to completely fund pensions.

Historically, calls for the creation of public pension guarantee funds, such as the PBGC, have followed the collapse of large employers with significantly underfunded pensions. Hence this theme that pension guarantee funds improve welfare by providing insurance seems quite appealing.

[39] Interestingly, Ippolito (1988) finds no evidence that the ERISA rules intended to promote fuller funding of pensions had any effect on actual funding levels from 1974–81. Some pension plans have indeed very low levels, if not quite zero, of funding. When LTV's Republic Steel terminated its pension plan in 1986, the plan had about \$230 million in liabilities and only about \$10,000 of assets (Weaver, 1997: 148).

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Yet, there are other, potentially offsetting effects of guarantee funds. Many of these have already been highlighted: under funding, upward-sloping compensation schedules and inefficient continuation decisions. Once these other concerns are taken into account, the net gains to a guarantee fund are less obvious.

To illustrate welfare losses from a guarantee fund, suppose that the firm is heavily capitalized so that $K \geqslant 2w^*$. From Proposition 1, this firm is quite capable of fully funding its own pension without any distortions in its continuation decision. Let $V^N(K)$ denote its expected profits from such a policy where

$$V^N(K) = K - 2w^* + \int_e^{\bar{A}} (A - e)dF(A)$$

Consider the implications of having this firm covered by a PBGC program with *ex ante* funding and $\overline{W}^o = w^*$. From Proposition 3, this firm will underfund its pension by setting $P = 0$ and will offer workers the first-best compensation profile, $w^y = w^o = w^*$. As noted before, the continuation decision is also distorted: the firm continues if and only if $A > e + w^*$. The expected profits of the firm under an *ex ante* guarantee fund are given by

$$V^F(K) = K - w^* + \tau^* + \int_{e+w^*}^{\bar{A}} (A - w^* - e)dF(A)$$

Using the determination of τ^* from (4′) and the probability of continuation as $(1 - F(e + w^*))$

$$V^F - V^N = w^*(1 - F(e + w^*)) - \int_{e+w^*}^{\bar{A}} w^* dF(A) - \int_e^{w^*+e} (A - e)dF(A)$$

This difference is negative as the first two terms cancel.

Thus, a firm with a high enough value of K actually loses by participating in the guarantee fund. It is instructive to understand this result. Clearly, this firm has no insurance gain from joining the fund. However, taking the *ex ante* premium as given the firm has no incentive to fund its pension. Instead, it relies entirely on the guarantee fund. This effect, itself, has no welfare implications: there are no gains to this insurance but also no losses. The welfare loss comes from the distortion in the exit decision. This is reflected in the last term of $V^F - V^N$. Note that this welfare loss is not a consequence of suboptimal behavior by the individual firm: it is optimally setting $P = 0$ and continuing if and only if this is profitable *ex post*.

The problem, as noted earlier, is with the lack of incentives within the fund. If the tax rate is directly related to the firm's underfunding level and appropriately set to reflect the distribution of profitability shocks, then appropriate funding can be realized and the fund will not reduce welfare. Of course, if there are firms with different levels of K or even different distributions of A, then tailoring the contract to a particular firm may not be feasible. Obviously if firms are made worse off for their participation in the fund they would only join if forced to by law or regulation. To the extent that compelling participation is easier to do with a public fund, such funds may have an additional advantage over their private counterparts.

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As another example of potential welfare losses, consider a firm with $K = w^*$. Further, suppose that the distribution of A has a lower support in excess of w^*. In this case, the firm can completely and credibly finance a pension promise of w^* from its flow of period 2 profits. Though workers face no uncertainty, this firm would be considered to have an underfunded pension. The firm does not have resources to pay an *ex ante* premium to a guarantee fund. Compelling its participation in a fund would be welfare-reducing.

To illustrate welfare gains, consider an example in which A can take only one of two values, A_L or A_H where $A_L < A_H$ and the probability of A_H is given by q. Relative to the case examined above, here we have restrictions such that the welfare losses from a distorted continuation decision do not arise so that we can focus on the insurance benefits of a fund. Thus, we assume that $A_L < e$, so that continuing is only efficient when A_H occurs. For *ex ante* contracting to be efficient, the expected gain from operating will exceed the minimum payments necessary to attract workers: i.e., $q(A_H - e) > 2w^*$.

At $K = w^*$, Proposition 2 implies that absent a fund the firm will not be able to achieve the first-best since it cannot promise its workers w^* in each period for certain. A fund might make this possible, however. If a firm with $K = w^*$ wanted to offer workers w^* in each period with the help of an *ex post* fund the fund will charge it z when the firm realizes A_H. In order for the fund to break even $z = (1 - q)w^*/q$. As long as the firm will choose to continue to operate in the A_H state given this charge, we will have restored the first-best outcome. The firm will find continuing profitable if

$$A_H > e + w^* + z = e + w^*/q$$

which must be true if the contract is *ex ante* efficient as given by the previous condition, $q(A_H - e) > 2w^*$. Since $V^F(K)$ is now at the first-best level, it is clearly higher than the value of the firm in the absence of a fund. In this case the fund has improved welfare. The key elements of this example are that the fund is providing insurance benefits, but it is not distorting the continuation decision.

Notice that it is important to this example that the workers are risk averse. When they are risk neutral we can write $u^* = 2w^*$ and recognize that any payment schedule that gives workers $2w^*$ in expectation will be sufficient to satisfy their individual rationality constraints. If $K = w^*$, the firm can then simply offer $w^y = w^*$ and $w^o = w^*/q$. The firm will be willing to honor this w^o if $A_H > e + w^*/q$ which will be the case if the contract is *ex ante* efficient: $q(A_H - \mathrm{e}) > 2w^*$.

Firms with large values of K will prefer not to be compelled to join such a guarantee fund. Note that this is true even if they pay a fair premium that accurately reflects the expected costs they impose on the fund. In fact, different types of firms are typically pooled together within a fund and charged premia that do not perfectly reflect the costs each firm imposes. This means that high K firms may be further hurt by the presence of a fund if they are forced to cross-subsidize lower K firms through inflated (to them) premia. Voluntary participation with common premia then runs the risk of familiar adverse selection problems.

Interestingly, the welfare loss of high K firms offering defined benefit plans guaranteed by the PBGC could be a motivation for the increased use of defined

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contribution plans. As noted earlier, defined contribution plans do not create distorted continuation decisions though they are funded up front. Thus, high K firms have an incentive to substitute towards this alternative form of pensions.

5.2 Compensation profiles

In the preceding analysis, the guarantee fund cap was set at w^* and thereby removed any incentive for employers to fund pensions. To the extent that different industries draw from very different labor markets, one would expect that w^* would be industry specific. Yet, the PBGC uses the same cap for all industries. As we shall see, this does produce the incentive to fund pensions in some industries and also creates an incentive to offer an upward-sloping compensation profile in others.

Given a cap on pension support, the optimal contracting problem of the firm can be written as in (3) where W^o denotes the income received by the worker in period two if the firm does not continue. To see the effects of the cap we consider two extreme cases. In the first, the cap is quite small relative to w^*. For the case of a near zero cap, the fund is irrelevant as the firm will effectively solve its optimization problem as if there was no guarantee fund (as in (1)). While the firm will have to make its contribution to the fund, the promised pension will exceed the cap and thus the promised payment from the fund is immaterial. The fund can only make a difference to workers if the firm drops its level of pension funding below the (near zero) cap, but we know that the firm was better off with a positive pension fund than with a one near zero. By continuity this argument holds even when the cap is positive but small relative to w^* for firms with large enough K to fund at least part of their own pension.

At the other extreme, consider an industry in which the cap exceeds w^*. This case illustrates the intuitive point that a more generous fund will elicit more generous pensions, a form of moral hazard. In particular, we know that at a cap of w^* the pension will not be funded and compensation profiles will be flat. As $\overline{W}^o$ increases above w^* then in the solution to (3) with a high cap we find that the compensation profile is tilted: $w^y < w^* < w^o$. To see this, consider how a firm would react to a slight increase of the cap above w^*. Recall that if the firm is initially setting $w^y = w^o = w^*$ the marginal utility of the worker will be the same in both periods. Now, consider transferring one dollar out of w^y and into w^o. The equality of the marginal utilities means that for such a small change the worker's utility will not be affected. However, the firm is better off because it saves one dollar of w^y with certainty in period one but pays the dollar extra of w^o in period two with a probability less than one $(1 - F(e + w^o))$. Though w^o may not rise to the level of the cap, as $\overline{W}^o$ increases, it certainly creates a distorted compensation profile.

5.3 Risky portfolios

The final implication of these guarantee funds we analyze concerns the pension portfolio. To this point the analysis has assumed that pension funds are invested in a riskless fund that has a zero return. This section considers the implications of allowing pensions to hold risky assets.

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In particular, suppose there is a risky asset available for pension investment with the same expected return. In the absence of a guarantee fund, one can argue directly that there is no reason for the pension fund to include this asset since the fund represents the interests of the risk-averse workers. However, pension funds generally do hold large amounts of risky assets and one explanation of low funding levels is below-expectation returns on the pension portfolio.

The pension fund's interest in investment in risky assets can be understood within our model as a consequence of the moral hazard created by the presence of a guarantee fund. We augment our model of a guarantee fund by allowing it to impose a minimal level of pension funding, denoted $\underline{P}$. We consider again our two-state special case in which A can take only one of two values, A_L or A_H where $A_L < e < A_H$ and the probability of A_H is given by q. Thus, by assumption, it is efficient for the firm to operate if and only if state A_H occurs.

Suppose that a firm can either invest its pension in the riskless asset or a risky asset. Assume that the risky asset pays $R > 1$ with probability π and zero otherwise. Let $\pi R = 1$ so that the return on the risky and riskless assets are the same. We assume that the firm can observe both the return on the pension portfolio and the realization of A before determining whether it will continue. Further we suppose that the firm has a large initial endowment and that the guarantee fund pays w^* to workers at bankrupt firms. From Proposition 3, the firm will offer a contract with $w^y = w^o = w^*$ and will, if unconstrained, set its pension to zero. With these assumptions, we can focus on the portfolio choice.

The value (V^{NR}) of the firm if it invests in the riskless asset is

$$V^{NR} = K - w^* - \underline{P} - \tau + q(A_H - e - w^* + \underline{P})$$

Here we have used the fact that the firm will operate only in the high state. If, instead, the firm invests in the risky asset, then its value is given by

$$V^R = K - w^* - \underline{P} - \tau + q(A_H - e - w^* + \pi R\underline{P}) + (1-q)\pi(A_L - e - w^* + R\underline{P})$$

Here the firm continues in operation in the high state regardless of the return on the pension and in the low state only if the pension return is R.[40]

The gain to investing in the risky asset is thus

$$\pi(1-q)(A_L - e - w^* + R\underline{P})$$

which is positive if $R\underline{P}$ is large enough. Interestingly, the firm is actually indifferent with regards to funding its pension when the risky investment is available – to see this note that V^R will be independent of $\underline{P}$ (i.e. the $\underline{P}$ terms cancel).[41] However, as argued in Proposition 3, they would strictly prefer $P = 0$ if all investment is riskless. Thus the gains associated with the risky investment provide an incentive for firms to fund their pensions![42] Note too that this gain to investing in risky assets is actually increasing

[40] Thus we are assuming that A_H is large enough to cover both e and w^*.

[41] This is true, in part, because we have assumed that R is large enough that a firm with a low realization of A will stay in operation if its pension plan achieves a return of R. In this case, the firm pays the full cost of an investment in the risky asset but also receives the full benefit.

[42] In fact, by continuity firms would be willing to invest in the risky portfolio even if the expected return was less than 1. This would represent an additional efficiency loss.

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in $\underline{P}$. Thus attempts by funds, such as the PBGC, to increase the funding of pensions may create an incentive for firms to adopt risky portfolios.

6 Conclusions

The purpose of this paper was to consider positive and normative aspects of public pension guarantee funds. To do so, we specified a model in which capital market imperfections could lead to the underfunding of pensions. In that case, the creation of a guarantee fund might improve risk sharing.

While a guarantee fund need not be public, our analysis reveals that a private guarantee fund has an inherent coordination problem, not unlike that of private deposit insurance schemes. A public guarantee fund, to the extent that there exists a commitment to subsidize the fund with tax revenues, has the virtue of avoiding coordination failure.

This public fund, therefore, does have the ability to provide more complete insurance to workers; a benefit of guarantee funds stressed in the early arguments in favor of public involvement. However, it must be recognized that this is not by itself a decisive argument in favour of public over private funds. As we have seen, both types of funds produce a number of potentially negative effects, such as: (i) the creation of a further incentive to underfund pensions, (ii) distorted decisions on the continuation of operations leading to inefficient exit from an industry and (iii) excessive risk taking through the inclusion of risky investments in the pension portfolio. Indeed, under the conditions of our model we have demonstrated that a guarantee fund actually hurts those firms with resources sufficient to fully fund their pensions, and that it may even lower total welfare. It is not at all clear that these offsetting costs will be the same under public and private funds – in our view, they must be a primary focus of a complete treatment of the absolute and relative merits of the two types of funds.

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Appendix

Proposition 1. *If $K \geqslant 2w^*$, $w^y = w^o = w^* = P$ and the exit decision will be efficient.*

Proof The first-order conditions from (1) are given by

$$-1+\lambda U'(w^y)-\phi=0 \tag{9}$$

$$-(1-F(w^o+e-P))+\lambda[f(w^o+e-P)\Delta U+(1-F(w^o+e-P))U'(w^o)]=0 \tag{10}$$

$$-1+(1-F(w^o+e-P))+\lambda[-f(w^o+e-P)\Delta U+F(w^o+e-P)U'(P)]-\phi+\gamma=0 \tag{11}$$

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where

$$\Delta U \equiv U(P) - U(w^o)$$

λ is the multiplier on the worker participation condition, ϕ is the multiplier on the constraint that $K \geqslant w^y + P$ and γ is the multiplier on the constraint that $P \geqslant 0$.

For K sufficiently large, we show that $w^y = w^o = w^* = P$ will satisfy these conditions with $\phi = 0$. At this proposed solution

$$1 = \lambda U'(w^y) = \lambda U'(w^o)$$

as $\Delta U = 0$ when $P = w^o$. Given the strict concavity of $U(\cdot)$, this condition implies $w^y = w^o$. At $P = w^o = w^y$ the first-order condition with respect to P is satisfied as well. $P > 0$ implies that $\gamma = 0$. With $w^y = w^o$, the worker's participation condition implies $w^y = w^o = w^*$. With $P = w^o$, the firm will continue if and only if $A > e$, which is the condition for efficient continuation.

Proposition 2. *If $K < 2w^*$, then $w^o > w^y > P$ and the firm will exit for some realizations of A such that continued operation is efficient.*

Proof With $K < 2w^*$, the contract characterized in Proposition 1 is not feasible so that $\phi > 0$. Further, since we assumed that $U'(c)$ goes to ∞ as c goes to 0, $\gamma = 0$. In this case, (9), (10) and (11) can be combined to yield

$$U'(w^y) = [(1-F)U'(w^o) + FU'(P)] \tag{12}$$

Here the cumulative distribution function, $F(\cdot)$, is evaluated at $(w^o + e - P)$. Using (12) along with the participation constraint and the restriction that $K < 2w^*$, we can show that $w^o > P$.

If $w^o = P$, then from (12), $w^y = w^o = P$ and from the worker's participation condition, these payments would equal w^*, as in the first-best contract. But this violates the assumption that $K < 2w^*$.

With $w^o > P$, (12) implies $w^o > w^y > P$. Hence we have an upward sloping wage profile and underfunding of the pension.

Finally, the underfunding distorts the continuation decision. The firm will remain active if and only if $A + P > w^o + e$ and with $w^o > P$, there are some realizations of A such that $A > e$ but the firm exits.

Proposition 3. *In the presence of a private guarantee fund with $\overline{W}^o = w^*$, if $K \geqslant w^* + \tau$ the firm will set $P = 0$ and $w^y = w^o = w^*$. Further, the firm will exit when continuation is efficient.*

Proof Taking derivatives of (3) with K assumed to be large enough that the borrowing constraint does not bind implies the following first-order conditions with respect to w^o, w^y and P

$$\begin{aligned}[1 - F(w^o - P + e + z)][\lambda U'(w^o) - 1] + \lambda f(w^o - P + e + z)[U(W^o) - U(w^o)] \\ + \lambda F(w^o - P + e + z) U'(W^o) \frac{dW^o}{dw^o} = 0\end{aligned} \tag{13}$$

$$1 = \lambda U'(w^y) \tag{14}$$

$$-1 + [1 - F(w^o - P + e - z)] - \lambda f(w^o - P + e - z)[U(W^o) - U(w^o)] \leqslant 0 \tag{15}$$

Here (15) holds as an equality if and only if the constraint that $P \geqslant 0$ does not bind. Given that the payment to workers is a non-differentiable function of w^o at $w^o = w^*$, the derivative in (13) is not defined everywhere. If $w^o > w^*$, then the derivative of W^o with respect to w^o equals zero. In this case, (13) and (14) imply that $w^y = w^o = w^*$. This contradicts $w^o > w^*$. If, instead, $w^o < w^*$, then the derivative of W^o with respect to w^o equals one. In this case, (13) and (14) imply that $w^o > w^*$. This contradicts $w^o < w^*$. Hence $w^o = w^*$ and therefore $w^y = w^*$ from the participation decision of the worker. Finally using $W^o = w^o$ in (15) implies that $P = 0$. Q.E.D.

Proposition 4. *In the presence of a private guarantee fund with $\overline{W}^o = w^*$, if $K < w^* + \tau$ the firm will set $w^y = K - \tau - P$, $w^o > w^* > w^y$ and $w^o > P$. Further, the firm will exit when continuation is efficient.*

Proof As $K = w^y + \tau + P$ and $K < w^* + \tau$, w^y must be less than w^*. With $\overline{W}^o = w^*$, $w^o > w^*$ from the workers individual rationality constraint. Finally, P is less than w^*. Suppose not: $P > w^*$. But then w^y would have to be negative since $K < w^* + \tau$. Since $w^o > w^*$, $w^o > P$: the pension is underfunded.

The firm will exit unless $A > w^o + \text{e} + z - P$. With $w^o > P$, exit will occur for some realizations of A in excess of e. This is inefficient.

Proposition 5. *If $W^o = w^*$, τ^* is given by (7) and (4′) holds, then there exist an equilibrium in which* ex post *assessments are zero and another equilibrium where the guarantee fund is bankrupt.*

Proof The strategic considerations in the continuation decisions of firms can be formalized as a game. The equilibrium of the game can be characterized by two cut-off values (A^*, α^*) such that firms continue if $A > A^*$ where the assessment level is determined using α^* as the equilibrium continuation probability. Formally, to be an equilibrium, (A^*, α^*) must satisfy:

$$\alpha^* = (1 - F(A^*)), \quad A^* = e + w^* + z(\alpha^*) \tag{16}$$

where $z(\alpha)$ is given by (4) with taxes at τ^* (7).

To study the equilibria of the *ex post* assessment game, we use (4′) to substitute the expression for A into that for α in (16). The resulting expression with α as the only unknown is

$$\alpha = 1 - F\left(e + w^* + \frac{(1-\alpha)w^* - \tau^*}{\alpha}\right) \equiv \xi(\alpha) \tag{17}$$

Clearly equilibria are given by fixed points of (17).

One equilibrium arises when there are no *ex post* assessments, $z = 0$. In this case, agents use the critical value of $A = e + w^*$ and α^* satisfies (17). The outcome coincides with that given in (4′) and (7) where no *ex post* assessments are anticipated and, in

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equilibrium, none are needed as the guarantee fund's resource constraint holds. In this equilibrium, $\alpha^* > 0$ as $F(e + w^*) < 1$.

To see that there may exist another equilibrium, consider $\alpha^* = 0$ so that *ex post* all firm's exit the market. From (17), $\xi(0) = 0$. Hence there exists a shutdown equilibrium to the *ex post* game as the guarantee fund is bankrupt. Q.E.D.

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