Discussion Paper Series

RIEB

Kobe University

DP2021-14

Contract Duration and Socially Responsible Investment

Meg ADACHI-SATO

May 11, 2021

Research Institute for Economics and Business Administration
Kobe University
2-1 Rokkodai, Nada, Kobe 657-8501 JAPAN

Contract Duration and Socially Responsible Investment*

Meg Adachi-Sato†

Initial version: May 10, 2020
Revised: Feb 18, 2021

Abstract

This paper shows how a socially and environmentally aware firm principal can motivate a profit-oriented manager to pursue environmental, social and governance (ESG) outcomes by adjusting the length and timing of wage contracts. In the model, the manager produces a verifiable output that is detrimental to ESG, but also engages in an unverifiable output that reduces ESG costs. The optimal arrangements are a short-term contract if the unverifiable output reduces ESG costs, and a long-term contract if it does not. The paper also demonstrates how social impact bonds can be more effective than short-term debt to finance social programs.

Keywords: Socially responsible investment, ESG, multitask, hold-up, incomplete contracts, social impact bonds, sustainability-linked bonds.

JEL Codes: D86, G11, G23, M12, M14

*This paper was presented at the Australian National University, the FIRN conference in Melbourne, Kyoto University, and RMIT University. The author is very grateful to Clara-Aimo A-S-Osano, Bruce Chapman, Neal Galpin, Hideshi Itoh, Kamiya Kazuya, Andrew Macrae, Hiroshi Osano, and David Stern for their useful advice about this work. This research is financially supported by Yu-cho Foundation (grant-in-aid for research 2020).

†School of Economics, Finance, and Marketing, RMIT University, Melbourne, VIC 3000, Australia. E-mail: meg.sato@rmit.edu.au. Research Institute for Economics & Business Administration, Kobe University, visiting research fellow, Nada-ku, Kobe, Japan. E-mail: megasato@diamond.kobe-u.ac.jp.

1 Introduction

Socially responsible investment (SRI) has attracted the interest of the investors, employees and consumers alike. Many investment funds, particularly socially responsible funds, consider asset allocation from an environmental, social, and governance (ESG) perspective. Despite this movement, firm managers often still pursue profit maximization. This article shows how principals can use the length and timing of wage contracts to motivate profit-maximizing managers to pursue socially responsible investment.

To this end, I address an effort (a firm-specific capital investment) allocation problem in the two-period multitask agency model following Holmstrom and Milgrom (1991). In this model, a manager of a firm must produce an observable and verifiable output x that incurs social costs or negative externality z, and an observable but unverifiable output y that reduces social costs z. Examples of x include normal day-to-day outputs or production. Examples of y include embedding a firm culture that values environmental and social issues, or that has policies and practices to combat bullying. A firm's culture is difficult to evaluate by outsiders (unverifiable), even though one can see or hear from the employees (observable).[1] If y is not reducing z at all, there is no point in engaging in the production of y.

To achieve these outputs, the manager must, during the first period, make an observable but unverifiable effort/investment in each task, denoted by I_x and I_y to increase the productivity to produce each output. An example of I_x is the amount of effort the manager has exerted in producing x, which is not only about the actual hours of work or the amount of money invested. An example of I_y is the manager's effort to cultivate a culture that values lowering the firm's environmental impact, as well as building transparency within the firm.

In reality, managers may pursue their own interest when choosing investments, rather than seeking to reduce social costs via unverifiable output. I assume, however, that the firm's principal values ESG, and wishes to reduce negative externalities. In this framework, I show that the

[1] In reality, there are both verifiable and unverifiable outputs that help reduce social costs. However, as we can see from the debate at the Davos conference, the line between verifiable and unverifiable outputs is rather grey when it comes to reducing social costs. Therefore, this paper focuses only on the unverifiable outputs that can reduce social costs. See for example Hughes, K., Sakano, A., Gore, A., Lacqua, F., Niinami, T. and Wijsen M. 2020, "Breaking Free from Single-Use Plastics", World Economic Forum Annual Meeting 2020, <https://jp.weforum.org/events/world-economic-forum-annual-meeting-2020/sessions/breaking-free-from-single-use >, accessed 5 May 2020.

principal can maximize her utility by selecting the length and the timing of wage contracts for the manager in a two-period model. There are two possibilities for such wage contracts: a short-term wage contract that determines the second-period wage at the beginning of the second period (ex post bargaining), and a long-term wage contract that determines the second-period wage at the beginning of the first period (ex ante commitment).[2] The short- and long-term wage contracts are distinguished by the timing of the offer for the second-period wage and who decides it.[3] As in practice, I assume that the manager is able to retain part of the surplus of the firm in the second period due to the firm-specific skills he obtains.

The sensitivity to which the unverifiable output reduces social costs is denoted by the parameter ζ. By definition, the larger ζ, the more useful the unverifiable output is in reducing social costs. The converse is also true: the smaller ζ, the less useful the unverifiable output in reducing social costs. The threshold for the principal equally preferring the short- and long-term wage contract is denoted by $\overline{\zeta}$, where $\overline{\zeta}$ is endogenously determined by the bargaining power of the agent, β .

In this model setting, I show that the decision of the principal to offer a short- or long-term wage contract depends on the sensitivity to which the unverifiable output reduces social costs. If the unverifiable output substantially contributes to reducing social costs, that is, the larger ζ, the more likely it is the principal will offer a short-term wage contract with a fixed wage.[4] Alternatively, if the unverifiable output does not substantially contribute to reducing social costs, that is, the smaller ζ, the more likely it is the principal will offer a long-term wage contract with incentive pay. These results hold regardless of whether the manager is risk neutral or risk averse. These results are obtained when the short-term wage contract is endogenously determined under the Nash bargaining solution, where the manager's and the principal's bargaining powers are the same.

[2] The length of the wage contract is not about how often the manager is fired; rather, it is about the frequency of renewing the wage contract. Unlike Inderst and Mueller (2010) and Adachi-Sato (2018), who examine optimal managerial compensation and replacement contracts, the manager remains employed under both wage contracts in this research. In addition, the long-term wage contract is renegotiation-proof because neither the principal nor the manager chooses any action in the second period.

[3] The first-period wage is determined at the beginning of the first period to satisfy the IR constraint in both types of contract. It does not affect the principal's choice of offering a short- or long-term contract because it is determined before the manager undertakes investment under either wage contract.

[4] I show in Section 3 that if the manager is risk neutral, it can be either a fixed wage or an incentive payment. I further show in Section 4 that if the manager is risk averse, the principal offers a fixed-wage contract

Moreover, by varying the manager's bargaining power under the generalized Nash bargaining solution (in a risk-neutral setting), I show how the principal's preference for the choice of contracts changes. Suppose the manager's bargaining power stays less than one-half ($0 < \beta < \frac{1}{2}$). In this setting, as β increases, the threshold regarding ζ shifts towards a small ζ, thereby enlarging the possibility of offering a short-term wage contract. Suppose the manager's bargaining power is larger than one-half ($\frac{1}{2} < \beta < 1$). In this setting, as β increases, the threshold regarding ζ shifts towards a large ζ, thereby lowering the possibility of the short-term wage contract will be chosen.

The intuition behind the first results is straightforward. If the principal offers the manager a second-period wage after the manager makes investments for both outputs (a short-term wage contract), the manager is given an incentive to invest during the first period in such a way that both verifiable and unverifiable outputs are produced. This is because the manager will wish to obtain a larger bargaining surplus (Nash product) by doing so.[5] The more the manager invests in the production of both the verifiable and unverifiable outputs, the larger the bargaining surplus. However, as the bargaining surplus must be split between both parties the hold-up problem arises. Thus, the investment for both outputs under the short-term wage contract is not the optimal level. If, however, the principal offers a second-period wage before the manager has made an effort towards either output (a long-term wage contract), the manager has no incentive to engage in producing the unverifiable output at all. Instead, the manager will be given a full incentive to engage in producing the verifiable output, because his wage will depend only on the verifiable output in the second period. Thus, the principal writes a contract that will induce the manager to achieve an investment level for the verifiable output, which maximizes the expected total net payoff generated by the firm. This means that a long-term contract is ideal when the verifiable output accompanies zero or small social costs, or when the principal does not care about reducing negative externalities caused by the verifiable outputs.[6] In short, incentive contracting (a long-term wage contract) and hold-up (a short-term wage contract) are alternative ways to motivate the manager to make socially responsible investments.

[5] The manager is no longer competitive at the beginning of the second period if he has invested during the first period because he has gained firm-specific skills.

[6] One example of the principal caring about the primary output that is observable and verifiable to detriment of social cost is the US President's pursuit of 'America first' policy while opting out of the Paris Agreement.

Intuitively, the second result is obtained by comparing how the marginal increase in the bargaining power β affects the expected utility of the principal under the short- and long-term wage contracts. I explain this using the case where the bargaining power of the agent stays smaller than that of the principal ($0 < \beta < \frac{1}{2}$). I will show later that the increase in the manager's bargaining power endogenously increases the investment. That is, the greater the manager's bargaining power, the less he fears hold-up, and the more investment he makes to create outputs. In this case, with the short-term wage contract, the principal's marginal expected utility exceeds the manager's marginal expected disutility caused by the incremental bargaining power. The manager's marginal expected disutility is synonymous with the principal's marginal expected cost, as she has to compensate for the manager's marginal expected disutility. As a result, the more bargaining power the manager obtains, the greater the principal's expected utility. With the long-term wage contract, the manager's reservation utility is fixed at the beginning of the first stage, and the change in the manager's bargaining power does not affect the expected utility of the principal. Thus, the principal's expected utility increases at the new threshold where the short-term wage contract is more likely to be chosen. Similar logic applies when the manager's bargaining power is between one-half and one, or when the bargaining power of the agent is larger than that of the principal's ($\frac{1}{2} < \beta < 1$).

The implications of my results are as follows. First, suppose a firm in which the unverifiable output can effectively reduce social costs or negative externalities caused by the verifiable output. In this case, it is better for the firm to hold wage negotiations frequently in order to promote socially responsible investment or activity if the firm's founder or the majority of the shareholders of the firm value ESG principles. On the other hand, for a firm in which the unverifiable output is not effectively reducing social costs, it is better not to hold wage negotiations too often. Furthermore, if verifiable and unverifiable outputs are managed by two different managers, future wages for the manager who will produce verifiable outputs should be agreed at the beginning of the initial contract, whereas future wages for the manager who is expected to produce unverifiable outputs should be negotiated more often. For example, managers who are paid fixed pay rather than incentive pay are generally motivated by promotion or wage renewal by promotion, as is the case for bureaucrats and officers and employees of public sector companies. Therefore, in equilibrium, governments or government-owned companies can reduce negative externalities by investing more in unverifiable outputs.

Second, a number of companies, such as ALCOA and Royal Dutch Shell, have recently started to embed ESG by tying executive pay to specific ESG targets. In terms of my model, this is like offering the long-term contract in which the wage is linked to some sort of signal of the social cost, z. This implies that if the specific ESG targets are imprecise or vague, it makes sense to offer a long-term wage contract. However, if the unverifiable output can substantially reduce social costs, such firms might consider adopting a contract that is similar to the short-term wage contract developed in this model.

Finally, my research can be applied to the analysis of social impact or sustainable-linked bonds. Under these arrangements, investors receive financial returns based on the accomplishment of predefined social objectives. Indeed, the optimal short-term wage contract characterized in this paper can be implemented using traditional short-term debts, whereas the optimal long-term wage contract can be implemented using social impact or sustainable-linked bonds. Accordingly, if achieving the higher social performance outcome involves more social disutility, traditional short-term debts are preferred to social impact (sustainable-linked) bonds. Conversely, if achieving the higher social performance outcome involves less social disutility, social impact (sustainable-linked) bonds are preferred to traditional short-term debts. In addition, when the investor's ex post bargaining power is smaller than the issuer's one, traditional short-term debts are more likely to be preferred, and when the investor's ex post bargaining power is greater than the issuer's one, social impact (sustainable-linked) bonds are more likely to be preferred as the manager's bargaining power increases.

The remainder of the paper is organized as follows. Section 2 discusses the related literature. Section 3 analyzes a risk-neutral agent. I also discuss limited liability constraints. Section 4 discusses a risk-averse agent. Section 5 studies the social impact and sustainability-linked bonds in the context of the models developed in this paper. The final section concludes.

2 Literature

The theoretical literature on socially responsible investing is limited. Heinkel, Kraus, and Zechner (2001) discuss a problem in which risk sharing is reduced when the firm is excluded by socially responsible investors. Hart and Zingales (2017) investigate a firm with prosocial investors who dislike social costs if they feel directly responsible for them.[7] Chowdhry, Davies, and Waters (2018) deal with the financing of a profit-maximizing firm and examine how socially minded investors induce the firm to commit to pursuing social goals. Morgan and Tumlinson (2019) study firm behavior, when shareholders care about public goods as well as profits, and when managerial compensation reflects these concerns. They show that managers can redirect more profits toward public good than shareholders would when acting separately. Furthermore, if public good is sufficiently desirable, they also indicate that the manager selects the socially optimal level of output. Opp and Oehmke (2020) examine the ability of socially responsible investors to influence firms by relaxing financial constraints for clean production, when firm production generates social costs and socially responsible investors care about externalities regardless of whether they are directly responsible for the social costs. Broccardo, Hart, and Zingales (2020) examine the relative effectiveness of exit (divestment and boycott) and voice (engagement) strategies in promoting socially desirable outcomes in companies. In contrast to these papers, I consider how the length and the timing of wage contracts induce the manager of the firm to pursue socially responsible investment or activity in a multitask principal-agent model following Holmstrom and Milgrom (1991).

The existing literature on combining contracts of different length is limited (Fudenberg, Holmstrom and Milgrom 1990, Ray and Salanie 1990). Moreover, these studies tend to confine their attention to how and when the principal can achieve the utility level of a long-term contract by repeating short-term contracts.[8] My paper shows that the principal is better off offering repeated short-term wage contracts than a long-term wage contract when the unverifiable output substantially contributes to reducing social costs caused by the verifiable output. On the other hand, the principal is better off if she offers a long-term contract when the unverifiable output does not substantially contribute to reducing social costs. My paper is one of the first to show that repeating short-term contracts can be strictly better than offering a long-term contract along with Kamiya and Adachi-Sato (2013) and Adachi-Sato and Kamiya (2013). Kamiya and Adachi-

[7] Extending the model of Heinkel, Kraus, and Zechner (2001), Pastor, Stambaugh, and Taylor (2020) derive an ESG factor in an asset-pricing equilibrium model. Also see Pederson, Fitzgibbons, Pomorski (2019).

[8] Dutta and Reichelstein (1996) show that short-term contracts can be better than a long-term contract in a different context. That is, in their model, agents get fired on the equilibrium path, and hence they allow agents to change sequentially. Their model-setting is different from mine in which the principal wishes to motivate one agent in a dynamic framework.

Sato (2013) present a general model of long-, short-, and medium-term wage contracts, which introduces for the first time in the literature the concept of medium-term contracts. Adachi-Sato and Kamiya (2013) develop a multi-task and job allocation model in which the agent has to produce not only verifiable but also unverifiable outputs where both outputs contribute to the firm's revenues in a framework as observed in actual labor markets. This paper is quite different from their paper in that I investigate an ESG investment problem with social cost generated from the verifiable output using the incomplete contract model, which can further be applied in the discussion of security design. In short, our papers examine completely different production processes: in my paper, the verifiable output contributes to the firm's revenue but generates the social cost of production, while the unverifiable output reduces the social cost of production. The concept of social costs and the sensitivity to which the unverifiable outputs reduces the social cost is original in my model. In so doing, and unlike any of the above-mentioned articles, this paper allows interpretation and examination of the use of social impact bonds.

Farrell and Shapiro (1989) and Bernheim and Whinston (1998) present models with verifiable and unverifiable attributes, where it is better not to contract, or to contract incompletely, over even verifiable attributes. My paper may seem somewhat similar to theirs. However, their logics are quite different from mine. Indeed, in Proposition 1 in Farrell and Shapiro, the seller does not prefer to sign a contract on verifiable attributes, because doing so becomes a constraint on optimizing unverifiable attributes. This argument has nothing to do with ex post bargaining, and cannot be applied to my case. This is because in my model, the principal does not choose any variables so as to optimize her utility after signing a contract. Bernheim and Whinston demonstrate that if some aspects of performance are noncontractible, it may be optimal to leave other verifiable aspects of performance unspecified. This is very different from my argument about the trade-off between ex ante commitment and ex post bargaining in inducing investments of the manager for verifiable and unverifiable outputs.

This paper contributes to the small but emerging body of literature on social impact or sustainable-linked bonds. Pauly and Swanson (2017) consider whether social impact bonds can finance projects that might not otherwise be undertaken using traditional bonds. They argue that social impact bonds will achieve greater program success if investors' efforts depend on incentives and can positively affect project outcomes. Tortorice, Bloom, Kirby, and Regan (2020) discuss a model of social impact bonds where there is asymmetric information about the probability of project success. They indicate that social impact bonds expand the set of implementable projects if the government is pessimistic about the likelihood of a project success, or if the government is averse to paying costs associated with a project in excess of benefits. However, these studies leave the question of whether social impact bonds will be effective under social programs with complex outputs. My model deals with this problem and considers the condition where social impact or sustainable-linked bonds are preferred to traditional short-term debts.

3 The Model: The Case of a Risk-neutral Agent

3.1 Model Setting

There is a principal, who delegates the management of her firm to a manager. I assume that both of them are risk neutral and care about their expected cash flows from the firm's project. However, only the principal cares about social costs of production. If the principal is a founder family of the firm, this can be justified by assuming that the founder family has a potential intrinsic motive not to cause social harm. If the principal is a fund, the fund is a socially responsible investor that follows ESG criteria.

There are two types of output produced by the firm. One is an observable and verifiable output $x > 0$ that generates not only the firm's revenue but also disutility of a nonpecuniary negative externality, expressed as a constant $z > 0$, which is interpreted as social cost to the principal that is aware of ESG. The other is an observable but unverifiable output $y > 0$ that reduces the principal's disutility by ζyz. The parameter $\zeta \geq 0$ is a sensitivity to which the unverifiable output reduces social costs. To focus on the role of y, in the subsequent analysis, I assume that z is an observable but unverifiable constant value. There are two verifiable output levels, x^H and x^L, where $x^H > x^L > 0$. The probabilities of x^H and x^L are denoted by $P^H \in [0, 1]$ and $P^L = 1 - P^H$. There are two unverifiable output levels, y^H and y^L, where $y^H > y^L > 0$. The probabilities of y^H and y^L are denoted by $Q^H \in [0, 1]$ and $Q^L = 1 - Q^H$. In the first period, the manager makes two types of effort (which I henceforth call investments) to generate outputs, $I_x \geq 0$ and $I_y \geq 0$, to increase the productivity for producing x and y, respectively. I assume that both I_x and I_y are observable but unverifiable, and that P^H and Q^H in the second period are functions of I_x and I_y, denoted by $P^H(I_x)$ and $Q^H(I_y)$, respectively. As is formally stated in Assumptions 1 and 2 imposed below, I assume that the random variables x and y are stochastically independent and that $P^H = Q^H = 0$ in the first period. That is, I assume that the investments in capital made in the first period will increase the manager's productivity from the second period onwards. The manager incurs disutilities in making the investments, denoted $D_x(I_x)$ and $D_y(I_y)$.

The wage for each period is paid at the end of each period, or after the realization of the outputs in each period.[9] As x is the only verifiable variable, the wage depends on the realization of x only: the wages for x^H and x^L are denoted by w^H and w^L, respectively. Let w_t^i denote w^i, $i = H, L$, in period $t = 1, 2$. Because of risk neutrality, w_2^i need not depend on the realization of x in the first period. I first investigate the model without limited liability constraints, and later provide similar results after imposing these constraints.

Note that there is no complementarity or substitutability between I_x and I_y, as x and y are stochastically independent and the total cost of the investments is additively separable, i.e., $D_x(I_x) + D_y(I_y)$.

Throughout this paper, I make the following assumption.

Assumption 0 $\quad x^L - z \geq 0$.

This assumption is justified if x^L is sufficiently large while z is not sufficiently large. It ensures the utilities of the principal and the agent during the second period under the short-term wage contract are nonnegative.

Next, the following assumptions on the functions D_x, D_y, P^H, and Q^H are standard.

Assumption 1 1. $\frac{dD_i}{dI_i} > 0$, $\frac{d^2 D_i}{dI_i^2} > 0$, $D_i(0) = 0$, and $\frac{dD_i(0)}{dI_i} = 0$, $i = x, y$.

2. $\frac{dP^H}{dI_x} > 0$ and $\frac{d^2 P^H}{dI_x^2} < 0$.

3. $\frac{dQ^H}{dI_y} > 0$ and $\frac{d^2 Q^H}{dI_y^2} < 0$.

4. The random variables x and y are stochastically independent.

In addition, for simplicity, I make the following assumption.[10]

[9] As the agent is risk neutral, I can consider a model in which the wages for both periods are paid together at the end of the second period. This is, however, a special case of a long-term contract.

[10] I can obtain what I would like to achieve in this analysis without this assumption. The assumption is imposed purely for the sake of simplifying the analysis.

Assumption 2 The probabilities of x^H and y^H are zero in the first period.

Under this assumption, the principal need not determine w_1^H in the first period.

I assume that at the initial bargaining stage, there are a lot of competitive managers; as a result, the principal is able to extract the full surplus of the firm. On the other hand, I also assume that the manager obtains some firm-specific skills in the first period. Thus, at the subsequent bargaining stage, the manager hired in the first period is able to retain part of the surplus because managers are no longer competitive. Hence, when the principal hires a manager in the first period, she posts a take-it-or-leave-it wage offer. After the manager has obtained firm-specific skills in the first period, the principal and the manager bargain over the wage at the beginning of the second period. For simplicity, I adopt Nash bargaining with a threat point set at $(0, 0)$. That is, I assume that their bargaining power is equal and that if they lose a partner, they cannot find any new partners, i.e., they can access the labor market only once and their reservation utilities are zero. It is worth noting that I can obtain similar results even if their bargaining power is different or their reservation utilities are nonzero in the second period.

Assumption 3 The principal posts a take-it-or-leave-it wage offer when a contract is signed at the beginning of the first period. The principal and the manager Nash bargain over wages with the threat point held at $(0, 0)$ when a contract is signed at the beginning of the second period.

I consider two types of wage contract: a short-term wage contract and a long-term wage contract. Under the short-term wage contract, wages are determined at the beginning of each period and paid at the end of each period. Under the long-term wage contract, wages for both periods are determined at the beginning of the first period but paid at the end of each period. I also discuss the limited liability constraint in Section 3.4, and demonstrate that similar results are obtained under the constraint.

3.2 The First-best Solution

I first determine the first-best optimal allocation without agency problems. With no agency conflict, the principal can determine the investment amounts I_x and I_y, by herself as follows:

$$\max_{I_x, I_y} x^L - (1 - \zeta y^L)z - D_x(I_x) - D_y(I_y) + \delta \left[\sum_{j=H,L} P^j(I_x)x^j - \sum_{j=H,L} Q^i(I_y)(1 - \zeta y^i)z \right].$$

The first-order conditions with respect to I_x and I_y for the above problem are given by

$$\frac{dD_x(I_x)}{dI_x} = \delta \frac{dP^H(I_x)}{dI_x}(x^H - x^L),$$

and

$$\frac{dD_y(I_y)}{dI_y} = \delta \frac{dQ^H(I_y)}{dI_y}\zeta(y^H - y^L).$$

Hence, the first-best investment levels are characterized by the above two equations.

3.3 A Short-term Wage Contract

Under the short-term wage contract, the principal offers the first-period wage at the beginning of the first period, and they bargain over the second-period wage at the beginning of the second period. The manager can make investments during the first period to maximize his own expected payoff. However, the principal cares about both her expected revenues and the social costs of production. Then, by Assumption 3, the principal's problem in the first period under the short-term wage contract is to make a take-it-or-leave-it offer on the first-period wage in order to induce the manager to implement the principal's preferred investment levels, subject to the individual rationality constraint and the incentive compatibility constraint on investments:

$$\max_{w_1^L, I_x, I_y} x^L - w_1^L - (1 - \zeta y^L)z + \delta V_2^p(I_x, I_y), \tag{1}$$

$$\text{s.t.} \quad w_1^L - D_x(I_x) - D_y(I_y) + \delta V_2^m(I_x, I_y) \geq u, \tag{2}$$

$$\begin{aligned} &w_1^L - D_x(I_x) - D_y(I_y) + \delta V_2^m(I_x, I_y) \\ &\geq w_1^L - D_x(I'_x) - D_y(I'_y) + \delta V_2^m(I'_x, I'_y), \ {}^\forall I'_x, I'_y, \end{aligned} \tag{3}$$

where $\delta \in (0,1)$ is the discount factor, $u > 0$ is the reservation utility determined in the competitive market, and $V_2^p(I_x, I_y)$ and $V_2^m(I_x, I_y)$ are the principal's and the manager's utilities in the second period when the investments are I_x and I_y, where $V_2^p(I_x, I_y)$ and $V_2^m(I_x, I_y)$ are determined by backward induction explained below. The individual rationality constraint is given by (2) and the incentive compatibility constraint is represented by (3).

The manager has bargaining power at the beginning of the second period. Applying Assumption 3, the principal and the manager Nash bargain over wages: for a given (I_x, I_y),

$$\max_{w_2^H, w_2^L} \left\{ \sum_{j=H,L} P^j(I_x)(x^j - w_2^j) - \sum_{i=H,L} Q^i(I_y)(1 - \zeta y^i)z \right\} \left\{ \sum_{j=H,L} P^j(I_x) w_2^j \right\}.$$

As both players are risk neutral, they obtain the same utilities from the Nash bargaining solution and this equals half of the total utility. Formally, their utilities are expressed as

$$V_2^p(I_x, I_y) = V_2^m(I_x, I_y) = \frac{1}{2}\left\{\sum_{j=H,L} P^j(I_x)x^j - \sum_{i=H,L} Q^i(I_y)(1-\zeta y^i)z\right\} \geq 0, \tag{4}$$

where the last inequality is evident from Assumption 0.

3.4 A Long-term Wage Contract

Under the long-term wage contract, the principal and the manager agree on the wages for both periods at the beginning of the first period. The manager can make investments during the first period. In line with Assumption 3, the principal's contracting problem is to make a take-it-or-leave-it offer on the first- and second-period wages in order to induce the manager to implement the principal's preferred investment levels, subject to the individual rationality constraint and the incentive compatibility constraint on investments:

$$\max_{w_1^L, I_x, I_y, w_2^H, w_2^L} x^L - w_1^L - (1-\zeta y^L)z + \delta\left[\sum_{j=H,L} P^j(I_x)(x^j - w_2^j) - \sum_{i=H,L} Q^i(I_y)(1-\zeta y^i)z\right], \tag{5}$$

$$\text{s.t.} \quad w_1^L - D_x(I_x) - D_y(I_y) + \delta \sum_{j=H,L} P^j(I_x)w_2^j \geq u, \tag{6}$$

$$\begin{aligned} & w_1^L - D_x(I_x) - D_y(I_y) + \delta \sum_{j=H,L} P^j(I_x)w_2^j \\ & \geq w_1^L - D_x(I_x') - D_y(I_y') + \delta \sum_{j=H,L} P^j(I_x')w_2^j, \forall I_x', I_y'. \end{aligned} \tag{7}$$

The principal's utility is given by (5). Inequalities (6) and (7) are the individual rationality and the incentive compatibility constraints of the manager.

3.5 A Comparison of the Two Types of Wage Contract

I explain below the mechanism through which the principal decides the wage profile and the frequency with which to renew the wage contract. The following proposition shows that the result depends on the effectiveness of y in reducing social costs, ζ.

Proposition 1 *1. There exists an optimal level of investment under the long-term wage contract for the verifiable output which maximizes the expected total net payoff generated by the firm if there were no social costs or if the principal or society neglect entirely the social cost. This optimal investment for the verifiable output is larger than that under the short-term wage contract.*

2. Under the long-term wage contract, w_2^H is strictly larger than w_2^L. Under the short-term wage contract, the fixed wage, i.e., $w_2^H = w_2^L$, can be offered.

3. There exists a threshold $\bar{\zeta} > 0$ such that the principal prefers a long-term to a short-term wage contract at the beginning of the first period for $\zeta \in [0, \bar{\zeta})$, and prefers a short-term to a long-term wage contract for $\zeta \in (\bar{\zeta}, \infty)$.

Proof: See Appendix A. ∎

Several remarks about Proposition 1 are in order. Under the short-term wage contract, the bargaining position/surplus of the manager at the beginning of the second period depends on his productivity in producing y as well as on his productivity in producing x. Thus, the principal can induce the agent to invest in I_y. However, the investment level for both outputs is reduced due to hold-up. Furthermore, a fixed wage can be used to motivate the manager, which is also true under the risk-averse setting which I prove in Proposition 4.

Under the long-term wage contract, at the beginning of the first period, the principal can offer a second-period wage depending on the output x the manager is going to produce in the second period. However, she cannot offer a second-period wage that reflects the amount of y the manager is going to produce in this period, as y is observable but unverifiable. As a result, the long-term wage contract cannot motivate the manager to invest in I_y at all, which is the investment to reduce social costs generated by x. However, the principal can motivate the manager to invest more in I_x by making w_2^H much larger than w_2^L. Indeed, the equilibrium level of I_x produces the optimal level for the verifiable output, which maximizes the expected total net payoff generated by the firm for both the first and second periods, including the social costs represented by z.

Under the long-term wage contract, the first-best allocation can be achieved if unverifiable output y is useless in reducing the social cost z, that is if $\zeta = 0$, and therefore there is no need to produce y, or formally $I_y = 0$. Given that the principal can set the manager's utility equal to u under the optimal long-term wage contract and that the short-term wage contract cannot achieve the first-best allocation, the principal strictly prefers the long-term wage contract when $\zeta = 0$. However, when ζ increases from 0, the investment allocation between I_x and I_y is distorted under the long-term wage contract. This is because in this situation the principal does not have any incentive schemes to control I_y, although I_y can reduce the social costs of I_x. As a result, the principal is forced to induce the manager to choose an inefficiently high level of I_x under the long-term wage contract. Because the principal has an incentive scheme to control I_y under the short-term wage contract, it is possible that she prefers the short-term wage contract to the long-term wage contract if ζ is sufficiently large.

Hence, the principal's choice between a short- and long-term wage contract depends on the sensitivity/effectiveness of y in reducing social costs of x. That is, if the principal values y more because it is effective at reducing the social costs of x, she prefers the short-term wage contract to the long-term wage contract. This means that if the principal wishes the manager to invest in both I_x and I_y from an ESG perspective, she will choose the short-term wage contract if y effectively reduces social costs.

The practical implications of Proposition 1 are as follows. First, in an industry or a firm where unverifiable outputs substantially contribute to a reduction in social costs caused by verifiable outputs, it is better to hold wage negotiations frequently; otherwise, it is better not to hold wage negotiations too often. In addition, even in the same firm, if one manager is mainly involved in producing verifiable outputs with social costs whereas the other manager is mainly involved in producing unverifiable outputs for reducing the social costs, then future wages for the former manager should be agreed at the beginning of the initial contract, whereas future wages for the latter manager should be negotiated more often.

Second, managers who are involved in producing unverifiable outputs and hence receive more fixed pay may be seen as motivated by promotion or wage renewal by promotion. This tendency towards promotion is significantly observed among managers in companies owned by central or local government. Thus, if these firms incur social costs, and they can reduce these costs overall with socially responsible investment, their government owners are more likely to be successful in persuading them to do so.

Finally, a number of companies have recently started embed ESG more deeply in their firms by relating executive pay to specific ESG targets.[11] However, if the specific ESG targets are imprecise or not relevant to the firm's ESG objective, these firms actually resemble a firm offering the long-term contract in my model. In this case, if the unverifiable output substantially contributes to reducing social costs, it may be better for the firm to hold wage negotiation frequently, like a firm offering the short-term contract in my model.

Next, I consider the effect of firm-specificity on the choice of contract duration. There are two ways to investigate the effect of firm-specificity of investments: one is to consider that (i) it is reflected in the threat point. The other is to consider that (ii) it is reflected in bargaining power. In (i), even if the threat point changes, it does not affect the choice of contract duration, because a contract with larger total utility would be chosen and this has nothing to do with the threat point. On the other hand, in (ii), the change in the bargaining power does affect the choice between the short and the long-term wage contracts.

Proposition 2 *If the manager's bargaining power comparatively increases, the principal is more (less) likely to offer the manager a short-term wage contract when* $0 < \beta < \frac{1}{2}$ *(*$\frac{1}{2} < \beta < 1$*).*

Proof: See Appendix B. ∎

Intuitively, the manager with strong bargaining power is not so afraid of hold-up. Hence, under the short-term wage contract, the manager has more incentive to make his investments for both verifiable and unverifiable outputs in order to achieve a larger bargaining surplus when his bargaining power is large enough. Indeed, when the manager's bargaining power stays smaller (or larger) than that of the principal's, the larger investments for both verifiable and unverifiable output in response to an increase in the manager's bargaining power increase (decrease) the principal's marginal utility of the investments relative to the manager's marginal disutility of the investments, that is, the principal's marginal cost of the investments. Hence, the larger

[11]For example, Royal Dutch Shell announced plans to tie executive pay to three-to five year targets for net carbon footprints from 2020 (see King, 2020). In ALCOA, 20 percent of executive cash compensation is tied to safety, environmental stewardship (including Greenhouse Gas Emissions reductions and energy efficiency), and diversity goals (see https://corpgov.law.harvard.edu/2019/09/10/executive-compensation-and-esg/).

investments due to an increase in the manager's bargaining power increase (or decrease) the principal's utility under the short-term wage contract. On the other hand, under the long-term wage contract, the manager's bargaining power has no effect on the principal's utility, because his wage is determined in the first period but his reservation utility is set equal to a constant level in the first period. Consequently, if the manager's bargaining power increases, the principal is more (or less) likely to offer the manager a short-term wage contract when the manager's bargaining power is smaller (or larger) than the principal's one.

The implication of this is that if the manager's bargaining power increases, the more (less) likely a long-term wage contract is chosen when the manager has more (less) bargaining power than the principal. Thus, when a manager cannot be substituted or replaced easily, the company is more likely to choose a long-term wage contract as the manager's bargaining power increases.

3.6 Limited Liability Constraints

I discuss below the role of limited liability constraints. I consider two types of constraints: (i) all wages are nonnegative,[12] and (ii) $w_1^L + \delta w_2^i \geq 0, i = H, L$.

For the short-term wage contract, I can set $w_2^H = w_2^L = V_2^m(I_x^*, I_y^*) \geq 0$, where I_x^* and I_y^* are the optimal investment levels chosen under the short-term wage contract (see (A2a) and (A2b) in Appendix A). Then, it follows from (2) that the principal must set

$$w_1^L + \delta w_2^i = D_x(I_x^*) + D_y(I_y^*) + u \geq 0, \qquad i = H, L.$$

Thus, the limited liability constraint of type (ii) is always satisfied. Moreover, if

$$D_x(I_x^*) + D_y(I_y^*) - \delta V_2^m(I_x^*, I_y^*) + u > 0, \tag{8}$$

then w_1^L can be nonnegative, that is, (i) is satisfied.

For the long-term wage contract, I can set $w_2^H = x^H - r$ and $w_2^L = x^L - r$, where r is the principal's utility in period two (see Appendix A). Then, it follows from (6) with $I_y^{**} = 0$ and Assumption 1.1 that the principal must set

$$\delta r = w_1^L - D_x(I_x^{**}) + \delta \sum_{j=H,L} P^j(I_x^{**}) x^j - u, \tag{9}$$

[12] This case can be interpreted by a minimum wage because the zero wage can be viewed as the minimum wage.

where I_x^{**} is the optimal investment level chosen under the long-term wage contract (see (A5)). Hence, using (9) with $x^H > x^L$ and $w_2^j = x^j - r$, $j = 1, 2$, I obtain

$$w_1^L + \delta w_2^H > w_1^L + \delta w_2^L = \delta x^L + D_x(I_x^{**}) - \delta \sum_{j=H,L} P^j(I_x^{**}) x^j + u.$$

The right-hand side is positive for a sufficiently large u, as I_x^{**} does not depend on u. Thus, the limited liability constraint of type (ii) is not binding for a sufficiently large u. Note that I can also find a sufficiently large u such that (i) is also satisfied. If I consider the case in which u is not sufficiently large, these limited liability constraints are binding under the long-term wage contract. Thus, the principal's utility under the long-term wage contract in the presence of these limited liability constraints is smaller than in their absence.

I now provide the following proposition that shows the result of Proposition 1.3 holds for the limited liability constraints of type (i) and (ii).

Proposition 3 *If a limited liability constraint is imposed, optimal contracts satisfy the following properties.*

1. *Under the long-term wage contract, w_2^H is larger than w_2^L. Under the short-term wage contract, a fixed wage, i.e., $w_2^H = w_2^L$, can be offered.*
2. *For the limited liability constraint of type (ii), there exists a $\bar{\zeta} > 0$ such that the principal prefers a long-term to a short-term wage contract at the beginning of the first period for $\zeta \in [0, \bar{\zeta})$, and prefers a short-term to a long-term wage contract for $\zeta \in (\bar{\zeta}, \infty)$. Next, if condition (8) is satisfied, the same result can be obtained for the limited liability constraint of type (i).*

Proof: See Appendix C. ▮

4 The Case of a Risk-averse Agent

In this section, I adopt the same model as in the preceding section, except that the manager's utility regarding his wage, w, is expressed as $U(w) = w^{1-\rho}$, where $0 \leq \rho < 1$, i.e., the case of constant relative risk aversion, and that the domain of w is the set of nonnegative real numbers, i.e., I impose the limited liability constraint of type (i).[13] I can show that the same results obtained in the preceding section hold for ρ close to zero, because all equilibrium values can be shown to be continuous functions of (ρ, ζ). Note that the risk-neutral case with the limited liability constraint of type (i) corresponds to the case of $\rho = 0$.

Proposition 4 *Suppose that*

$$D_x(I_x^*) + D_y(I_y^*) - \delta V_2^m(I_x^*, I_y^*) + u > 0,$$

where I_x^* and I_y^* are the optimal investment levels chosen under the short-term wage contract when $\rho = 0$, and that $P^H(I_x) \in (0,1)$ for all I_x. Then, there exists a $\bar{\rho} \in (0,1)$ such that the following properties hold for all $\rho \in (0, \bar{\rho}]$:

1. *Under the long-term wage contract, w_2^H is larger than w_2^L, and under the short-term wage contract, the fixed wage, i.e., $w_2^H = w_2^L$, is offered.*

2. *There exists a $\bar{\zeta} > 0$ such that the principal prefers a long-term to a short-term wage contract at the beginning of the first period for $\zeta \in [0, \bar{\zeta})$, and prefers a short-term to a long-term wage contract for $\zeta \in (\bar{\zeta}, \infty)$.*

Proof: See Appendix D. ∎

5 Extensions: Social Impact and Sustainability-linked Bonds

The analysis of this article can also apply to the issue of how financial investing that considers an ESG impact in its investment choice is organized to improve the performance of the social program. In this field, there are two types of bonds: social impact bonds issued by a public entity and sustainability-linked bonds issued by any company or public entity. In the subsequent analysis, I focus on social impact bonds and compare them with traditional short-term borrowings, although sustainability-linked bonds are investigated at the final part of this section.[14]

[13] As I can derive similar results when the manager can save, I do not discuss savings for simplicity. Note that there is no need to consider savings for the risk-neutral manager if the saving interest rate is smaller than or equal to δ.

[14] For simplicity, in the subsequent discussion, I assume there is no default, regardless of whether the issuer uses traditional short-term debts, or social impact bonds or sustainability-linked bonds. This implies that the issuer has enough funds to repay debt or bond payments, even though for political reasons it cannot make enough funds available for the project prior to proven success.

The general structure of the social impact bond is as follows. A issuer borrows funds from a private for-profit investor to execute a social program. The issuer is most often a public entity with altruistic preferences, that is, the (local) government. The issuer then furnishes the funds to a nonprofit service provider that needs to finance up-front costs to execute the program. For the sake of simplicity, I assume that the issuer and the nonprofit service provider are fully integrated.[15] The issuer and the investor then agree to a performance-contingent debt contract that allows the issuer to pay only in the event that a pre-defined performance target is met. More specifically, if the program successfully attains the target, the issuer pays both principal and interest; but if the program does not achieve the target, the issuer pays nothing in most cases. Furthermore, the social impact bond induces the private investor to exert an effort to positively influence program performance. Indeed, the private investor not only expresses his concern about the social program and the current inability of the government to deal with it, but also can offer specific ideas about methods and techniques to solve the problem. Pauly and Swanson (2017) present evidence that existing social impact bonds engage private investors with program-specific expertise to improve program performance (see Section 6 and Appendix A in their study).[16]

The issuer also uses traditional short-term debt at each period: the issuer then needs to pay both principal and interest to the private investor so that it shoulders all the financial risk associated with the funded program. In addition to the social impact bond and traditional short-term debt, I assume that the issuer can also obtain a part of the funds from two sources: government transfer and philanthropic donations.

The timing of the model is as follows. At the beginning of period 1, the issuer offers the social impact bond or traditional short-term debt to the private investor in order to improve the performance of the social program by financing a part of up-front costs that exceeds the amount funded by the government transfer and philanthropic donations. During periods 1 and 2, the program is executed. If the issuer uses traditional short-term debt, it rolls over the short-term debt at the beginning of period 2. At the end of period 2, the program's final success or failure

[15] Tortorice, Bloom, Kirby, and Regan (2020) make the same assumption.

[16] Managers of nonprofit service providers may also exert productive effort. However, to focus on the role of the private investor, I assume here that their productive effort is fixed and invariant irrespective of the financing method.

is realized. Under the social impact bond, the issuer pays both principal and interest only if the program can successfully attain the targets; whereas under traditional short-term debt, the issuer must pay both principal and interest at any state.

To apply the optimal contracting analysis of the previous sections, note that the issuer can be interpreted as the principal, and the private investor as the manager. The issuer needs to finance up-front capital expenditures u to execute the social program. If the social program is executed, the performance outcome of the social program for the issuer is measured by the observable and contractible output $x > 0$. However, this program may generate disutility for program participants or running cost (exclusive of u), $z > 0$, that reduces the issuer's utility where z is observable but noncontractible.[17] However, if the observable but noncontractible output $y > 0$ is produced, the principal's disutility is reduced by ζyz. The observable but noncontractible effort $I_x \geq 0$ and $I_y \geq 0$ can be viewed as the private investor's effort to increase productivity for the production of x and y, respectively.[18]

The short-term wage contract given in the previous sections can be transformed into traditional short-term debt, and the long-term wage contract into social impact bond. For traditional short-term debt, I consider that the issuer borrows $u - w_1^L$ from the private investor at the beginning of period 1, rolls over the short-term debt at the beginning of period 2, and makes a fixed payment to the private investor at the end of period 2, where w_1^L indicates the amount funded by the government transfer and philanthropic donations. On the other hand, for the social impact bond, I consider that the issuer offers a performance-contingent bond at the beginning of period 1: he borrows $u - w_1^L$ from the private investor at the beginning of period 1 and pays w_2^H (w_2^L) to the private investor at the end of period 2 if the pre-specified performance outcome is (is not) met, that is , $x = x^H$ (x^L). This interpretation particularly holds true if x^L is sufficiently small.

Suppose the issuer uses short-term debt to finance the social program. Then, at the beginning of period 1, the issuer offers short-term debt to maximize her expected utility represented by (1), subject to the following constraints: the private investor's participation constraint, (2), which ensures that his net expected payoff at the beginning of period 1 is equal to the lending amount

[17] For example, in prisoner rehabilitation program, the better performance outcome of the program may increase effort disutility of prisoners or additional running costs of prisons.

[18] The private investor's effort can also be viewed as his effort to apply his specific ideas about methods and technique in order to solve the design and management problem.

$u - w_1^L$, and his incentive compatibility constraint, (3), which implies that he chooses his efforts during the first period to maximize his own net expected payoff at the beginning of period 1. Because the private investor obtains some program-specific skills in period 1, he has bargaining power at the beginning of period 2. Hence, the issuer and the private investor Nash bargain over the period 2 debt payment, as indicated by the bargaining problem characterized in Section 3.1.

Next, suppose that the issuer uses the social impact bond to finance the social program. Then, at the beginning of period 1, the issuer and the private investor agree on the debt payment contingent on the observable performance outcome x at the end of period 2. Hence, the issuer offers the social impact bond to maximize her expected utility represented by (5) subject to the individual rationality constraint for the private investor, (6), and the incentive compatibility constraint on efforts for the private investor, (7).

These arguments show that the optimal contracts derived in the previous sections can be implemented as follows: the optimal short-term wage contract can be implemented using traditional short-term debt, whereas the optimal long-term wage contract can be implemented using the social impact bond.

Accordingly, applying Propositions 1 and 2, I obtain the following proposition.

Proposition 5 *1. There exists a $\overline{\zeta} > 0$ such that the issuer prefers the social impact bond to traditional short-term debt at the beginning of the first period for $\zeta \in [0, \overline{\zeta})$, and prefers traditional short-term debt to the social impact bond for $\zeta \in (\overline{\zeta}, \infty)$.*

2. If the private investor had more bargaining power, the issuer is more likely to offer the private investor the short-term debt if $0 < \beta < \frac{1}{2}$ and less likely if $\frac{1}{2} < \beta < 1$.

The implications of this proposition are provided as follows. First, the social impact bond gives more incentive for the private investor to make efforts to achieve the higher performance outcome with social cost by offering him contingent debt payments. Moreover, under the social impact bond, the equilibrium effort level for the higher performance outcome maximizes the expected total net utility enjoyed by the issuer who does not consider social cost.

Second, traditional short-term debt motivates the private investor to make efforts both to achieve the higher performance outcome with social cost and to reduce social cost; however, the effort level for the higher performance outcome is not the one that maximizes the expected total net utility generated by the issuer (who, again, does not consider social cost).

Third, if the effectiveness of y in reducing social cost, ζ, improves, the issuer is more likely to prefer traditional short-term debt to the social impact bond. In other words, if achieving the higher performance outcome involves more cost, the issuer is more likely to choose traditional short-term debt.

Finally, if the private investor's bargaining power increases, the more (less) likely the social impact bond is chosen when he has more (less) bargaining power than the issuer. Thus, when the current private investor cannot be substituted or replaced easily, the issuer is more likely to choose the social impact bond if the private investor's bargaining power increases.

In the case of sustainability-linked bonds, which have the financial features that vary according to whether the issuer achieves predefined ESG key performance indicators, these bonds can be issued by any for-profit company or public entity with access to capital markets.[19] If the likelihood of the issuer meeting the target for key performance indicators highly depends on the effort or monitoring of investors, the analysis of this section is applicable to the case of sustainability-linked bonds.

6 Conclusion

In this article, I explore how a profit-maximizing manager can be motivated to pursue socially responsible investment by adjusting the length and the timing of wage contracts. I have shown that incentive contracting (a long-term wage contract) and hold-up (a short-term wage contract) are alternative ways to motivate the manager to make socially responsible investments. That is, a long-term wage contract does not allow for hold-up and induces the manager's investment for a verifiable output with social costs, but also removes the manager's investment incentive for an unverifiable output that reduces social costs. A short-term wage contract allows for greater hold-up and reduces the manager's investment incentive for the verifiable output, but promotes the manager's investment incentive for the unverifiable output. Hence, an appropriate use of contracts of different length can mitigate the inefficiency caused by the trade-off.

Whether the principal offers a short- or long-term wage contract depends on how the unverifi-

[19] For sustainability-linked bonds, see Uzsoki (2020).

able output contributes to reducing social costs caused by the verifiable output. If the unverifiable output substantially contributes to reducing social costs, the principal offers a short-term wage contract with a fixed wage. Alternatively, if the unverifiable output does not substantially contribute to reducing social costs, the principal offers a long-term wage contract with incentive pay. These results hold regardless of whether the manager is risk neutral or risk averse. In addition, under the risk-neutral setting, if the manager's bargaining power increases, the principal is more likely to offer the manager a short-term wage contract when the manager's bargaining power is smaller than that of the principal's, and less likely if it is larger.

An useful implication of this study is to investigate whether a social impact or sustainability-linked bond is preferred to traditional short-term debt when financial investing involves ESG impact.

References

Adachi-Sato, Meg, "Stock Vesting Conditions, Control benefits and Managerial Replacement," *Canadian Journal of Economics*, February 2018, 51(1), 275–313.

Adachi-Sato, Meg, and Kamiya, Kazuya, "A Dynamic Multitask Model: Fixed Wages, No Externalities, and Holdup Problems," CIRJE-F-825, 2013.

Bernheim, B. Douglas and Whinston, Michael D., "Incomplete Contracts and Strategic Ambiguity," *American Economic Review*, September 1998, 88(4), 902–32.

Broccardo, Eleonora, Hart, Oliver D., and Zingales, Luigi, "Exit VS. Voice," NBER Working Paper, 2020, 27710.

Chowdhry, Bhagwan, Davies, Shaun William, and Water, Brian, "Investing for Impact," *Review of Financial Studies*, 2018, 32(3), 864–904.

Dutta, Sunil and Reichelstein, Stefan, "Leading Indicator Variables, Performance Measurement and Long-Term versus Short-Term Contracts," *Journal of Accounting Research*, December 2003, 41(5), 83–66.

Farrell, Joseph, and Shapiro, Carl, "Optimal Contracts with Lock-In," *American Economic Review*, March 1989, 79(1), 51–68.

Fudenberg, Drew, Holmstrom, Bengt, and Milgrom, Paul, "Short-term Contracts and Long-term Agency Relationships," *Journal of Economic Theory*, June 1990, 51(1), 1–31.

Hart, Oliver and Zingales, Luigi, "Companies Should Maximize Shareholder Welfare Not Market Value," *Journal of Law, Finance, and Accounting*, 2017, 2(2), 247–275.

Heinkel, Robert, Kraus, Alan, and Zechner, Josef, "The Effect of Green Investment on Corporate Behavior," *Journal of Financial and Quantitative Analysis*, 2001, 36(4), 431–449.

Hildenbrand, Werner, *Core and Equilibria of a Large Economy*, 1974, Princeton University Press, Princeton, New Jersey.

Holmstrom, Bengt and Milgrom, Paul, "Multi-task Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design," *Journal of Law, Economics, and Organization*, 1991, 7(Special Issue), 24–52.

Hughes, K., Sakano, A., Gore, A., Lacqua, F., Niinami, T. and Wijsen M, "Breaking Free from Single-Use Plastics," World Economic Forum Annual Meeting 2020, https://jp.weforum.org/

events/world-economic-forum-annual-meeting-2020/sessions/ breaking-free-from-single-use >, accessed, May 5, 2020.

Inderst, Roman and Mueller, Holger M., "CEO Replacement under Private Information," *Review of Financial Studies*, 2010, 23(8), 2935–2969.

Kamiya, Kazuya, and Sato, Meg, "Multiperiod Contract Problems with Verifiable and Unverifiable Outputs," 2013, Mimeo.

King, Timothy, "The Many Questions of Tying ESG to Executive Compensation," https://boardmember.com/questions-tying-esg-executive-compensation/, Corporate Board Member.

Morgan, John, and Tumlinson, Justin, "Corporate Provision of Public Goods," *Management Science*, 2019, 65(10), 4489–4504.

Opp, Marcus, and Oehmke, Martin, "A Theory of Socially Responsible Investment," CEPR Discussion Paper, 2020, DP14351.

Pastor, Lubos, Stambaugh, Robert F, and Taylor, Lucian A., "Sustainable Investing in Equilibrium," *Journal of Financial Economics*, forthcoming.

Pauly, Mark V., and Swanson, Ashley, "Social Impact Bonds: New Product or New Package?" *Journal of Law, Economics, and Organization*, 2017, 33(4), 718–760.

Pederson, Lasse Heje, Fitzgibbons, Shaun, and Pamorski, Lukasz, "Responsible Investing: The ESG-Efficient Frontier," SSRN Working Paper, 2019, No.3466417.

Ray, Patrick and Salanie, Bernard, "Long-term, Short-term and Renegotiation: On the Value of Commitment in Contracting," *Econometrica*, 1990, 58, 597–619.

Tortorice, Daniel L, Bloom, David, E., Paige, Kirby, and Regan, John, "A Theory of Social Impact Bonds," NBER Working Paper, 2020, 27527.

Uzsoki, David, "Sustainability-Linked Bonds: A New Way to Finance COVID-19 Stimulus," https://www.iisd.org/articles/sustainability-linked-bonds, July 22, 2020.

Appendices

A. Proof of Proposition 1

A Short-term Wage Contract

In the first period, given (4) and $\sum_{i=H,L} Q^i(I_y) = 1$, (3) is rearranged so that the manager chooses I_x and I_y satisfying the following incentive compatibility constraint:

$$\max w_1^L - D_x(I_x) - D_y(I_y) + \frac{1}{2}\delta \left[\sum_{j=H,L} P^j(I_x)x^j - z + \sum_{i=H,L} Q^i(I_y)\zeta y^i z \right]. \tag{A1}$$

The first-order conditions then yield

$$\frac{dD_x(I_x)}{dI_x} = \frac{1}{2}\delta \frac{dP^H(I_x)}{dI_x}(x^H - x^L), \tag{A2a}$$

and

$$\frac{dD_y(I_y)}{dI_y} = \frac{1}{2}\delta \frac{dQ^H(I_y)}{dI_y}\zeta(y^H - y^L)z. \tag{A2b}$$

Note that by Assumption 1 the second-order conditions are satisfied. Let the solutions of the above equations be I_x^* and I_y^*. On the other hand, it follows from (2) that the principal must set

$$w_1^L = D_x(I_x^*) + D_y(I_y^*) - \delta V_2^m(I_x^*, I_y^*) + u. \tag{A3}$$

As discussed in the text, the Nash bargaining solution is (4), that is,

$$V_2^m(I_x^*, I_y^*) = V_2^p(I_x^*, I_y^*) = \frac{1}{2} \left[\sum_{j=H,L} P^j(I_x^*)x^j - z + \sum_{i=H,L} Q^i(I_y^*)\zeta y^i z \right].$$

Then, from (A3) that the principal's expected utility, (1), is obtained as follows:

$$\begin{aligned} x^L - w_1^L - (1-\zeta y^L)z + \delta V_2^p(I_x^*, I_y^*) &= x^L - (1-\zeta y^L)z - D_x(I_x^*) - D_y(I_y^*) + 2\delta V_2^p(I_x^*, I_y^*) - u \\ &= x^L - (1-\zeta y^L)z - D_x(I_x^*) - D_y(I_y^*) \\ &\quad + \delta \left[\textstyle\sum_{j=H,L} P^j(I_x^*)x^j - z + \sum_{i=H,L} Q^i(I_y^*)\zeta y^i z \right] - u. \end{aligned} \tag{A4}$$

Finally, as discussed in the text, the Nash bargaining solution shows that the principal can choose a fixed wage, i.e.,

$$w_2^H = w_2^L = V_2^m(I_x^*, I_y^*) = \frac{1}{2} \left[\sum_{j=H,L} P^j(I_x^*)x^j - z + \sum_{i=H,L} Q^i(I_y^*)\zeta y^i z \right].$$

∎

A Long-term Wage Contract

Let I_y^{**} be the optimal investment level that satisfies (7). Then, from Assumption 1.1, $I_y^{**} = 0$. Suppose that $w_2^j = x^j - r$, $j = H, L$, where r is the principal's utility in period two. Then, substituting $w_2^j = x^j - r$, $j = H, L$, into (7), I obtain the following first-order condition with respect to I_x:

$$\frac{dD_x(I_x)}{dI_x} = \delta \frac{dP^H(I_x)}{dI_x}(x^H - x^L). \tag{A5}$$

Let I_x^{**} be the solution.

On the other hand, I can consider the following maximization problem of the joint utility of the principal and the manager for $I_x^{**} = 0$:

$$x^L - (1 - \zeta y^L)z - D_x(I_x) + \delta \left(\sum_{j=H,L} P^j(I_x)x^j - z + \sum_{i=H,L} Q^i(0)\zeta y^i z \right). \tag{A6}$$

Note that $D_y(0) = 0$. Then, it is evident that the first-order condition with respect to I_x is again obtained by (A5). Under Assumptions 1.1 and 1.3, this implies that I_x^{**} also maximizes the joint utility of the principal and the manager when $I_y^{**} = 0$.

Using (6) with $I_y^{**} = 0$, the principal must set

$$w_1^L = D_x(I_x^{**}) - \delta \sum_{j=H,L} P^j(I_x^{**})w_2^j + u. \tag{A7}$$

Then, the principal's utility, (5), for $I_y^{**} = 0$ is expressed as follows:

$$\begin{aligned} &x^L - w_1^L - (1 - \zeta y^L)z + \delta \left[\textstyle\sum_{j=H,L} P^j(I_x^{**})(x^j - w_2^j) - z + \sum_{i=H,L} Q^i(0)\zeta y^i z \right] \\ &= x^L - (1 - \zeta y^L)z - D_x(I_x^{**}) + \delta \left[\textstyle\sum_{j=H,L} P^j(I_x^{**})x^j - z + \sum_{i=H,L} Q^i(0)\zeta y^i z \right] - u. \end{aligned} \tag{A8}$$

As has been shown above, when $I_y^{**} = 0$, I_x^{**} maximizes the joint utility of the principal and the manager, and satisfies (6) and (7) for $w_2^j = x^j - r$, $j = H, L$. Given that the manager's reservation utility is set equal to a constant level u, these findings show that the optimal long-term wage contract consists of $(I_x, I_y) = (I_x^{**}, I_y^{**}) = (I_x^{**}, 0)$ and $w_2^j = x^j - r$, $j = H, L$. Finally, it follows from $w_2^j = x^j - r, j = H, L$, that w_2^H is larger than w_2^L. ∎

A Comparison of Two Types of Contract

First, comparing (A2a) and (A5), the manager undertakes more investment in I_x under the long-term wage contract than under the short-term wage contract, i.e., $I_x^* < I_x^{**}$.

When $\zeta = 0$, the principal prefers the long-term wage contract to the short-term wage contract, i.e., (A8) is larger than (A4). Indeed, when $\zeta = 0$, it follows from (A2b) with $\frac{dD_y(0)}{dI_y} = 0$ that $I_y^* = 0$ is chosen even in the short-term wage contract. Thus, using $\zeta = I_y^* = I_y^{**} = 0$,

$$(\text{A8}) - (\text{A4}) = -D_x(I_x^{**}) + \delta \sum_{j=H,L} P^j(I_x^{**})x^j - \left(-D_x(I_x^*) + \delta \sum_{j=H,L} P^j(I_x^*)x^j \right) > 0.$$

The last inequality follows from (A5), i.e., I_x^{**} satisfies the first-order condition for maximizing $-D_x(I_x) + \delta \sum_{j=H,L} P^j(I_x)x^j$.

To investigate the effect of an increase in ζ on the choice of contracts, using (A4) and (A8), I only need to investigate

$$\kappa(\zeta) = -D_y(I_y^*) + \delta \sum_{i=H,L} \left[Q^i(I_y) - Q^i(0)\right] \zeta y^i z,$$

because (A2a) and (A5) imply that neither I_x^* nor I_x^{**} depends on ζ.

Then, it follows from (A2b) with Assumptions 1.1 and 1.3 that

$$\kappa'(\zeta) = \frac{\delta}{2} \frac{dQ^H(I_y^*)}{dI_y^*} \zeta (y^H - y^L) z \cdot \frac{dI_y^*}{d\zeta} + \delta \sum_{i=H,L} \left[Q^i(I_y^*)) - Q^i(0)\right] y^i z,$$

where

$$\frac{dI_y^*}{d\zeta} = \frac{\frac{\delta}{2} \frac{dQ^H(I_y^*)}{dI_y^*}(y^H - y^L)z}{\frac{d^2 D_y(I_y^*)}{dI_y^{*2}} - \frac{\delta}{2} \frac{d^2 Q^H(I_y^*)}{dI_y^{*2}} \zeta (y^H - y^L) z} > 0. \tag{A9}$$

Note that κ is a strictly increasing function of ζ, and goes towards $+\infty$ as ζ goes towards $+\infty$. This implies that the principal's utility under the short-term wage contract, (A4), is larger than that under the long-term wage contract, (A8), when ζ is sufficiently large. In contrast, when $\zeta = 0$, the principal strictly prefers the long-term wage contract to the short-term wage contract. Thus, there exists a $\overline{\zeta} > 0$ such that the principal prefers the long-term wage contract to the short-term wage contract for $\zeta \in [0, \overline{\zeta})$, and prefers the short-term wage contract to the long-term wage contract for $\zeta \in (\overline{\zeta}, \infty)$. ∎

B. Proof of Proposition 2

Let the bargaining power of the principal and the manager be $1-\beta$ and β. Then the second period bargaining becomes:

$$\max_{w_2^H, w_2^L} \left[\sum_{j=H,L} P^j(I_x)(x^j - w_2^j) - z + \sum_{i=H,L} Q^i(I_y)\zeta y^i z \right]^{1-\beta} \left[\sum_{j=H,L} P^j(I_x) w_2^j \right]^{\beta}. \tag{B1}$$

Applying the generalized Nash bargaining solution to (B1), I can obtain

$$V_2^p(I_x, I_y) = (1-\beta) \left[\sum_{j=H,L} P^j(I_x) x^j - z + \sum_{i=H,L} Q^i(I_y)\zeta y^i z \right], \tag{B2}$$

$$V_2^m(I_x, I_y) = \beta \left[\sum_{j=H,L} P^j(I_x) x^j - z + \sum_{i=H,L} Q^i(I_y)\zeta y^i z \right]. \tag{B3}$$

Repeating a procedure similar to that used in the proof of Proposition 1, I can also show that the first-order conditions with respect to I_x and I_y under the short-term wage contract are as follows:

$$\frac{dD_x(I_x)}{dI_x} = \beta\delta \frac{dP^H(I_x)}{dI_x}(x^H - x^L), \tag{B4}$$

$$\frac{dD_y(I_y)}{dI_y} = \beta\delta\zeta \frac{dQ^H(I_y)}{dI_y}(y^H - y^L)z. \tag{B5}$$

Define $\widehat{I}_x^*$ and $\widehat{I}_y^*$ as I_x and I_y that satisfy (B4) and (B5). Let $\Psi(I_x, I_y)$ denote the principal's utility attained in period 1 under the short-term wage contract.[20] Repeating a similar procedure used in the proof of Proposition 1, I can derive

$$\begin{aligned} \Psi(\widehat{I}_x^*, \widehat{I}_y^*) = \quad & x^L - (1-\zeta y^L)z - D_x(\widehat{I}_x^*) - D_y(\widehat{I}_y^*) \\ & + \delta(1-\beta) \left[\sum_{j=H,L} P^j(\widehat{I}_x^*) x^j - z + \sum_{i=H,L} Q^i(\widehat{I}_y^*)\zeta y^i z \right] - u. \end{aligned} \tag{B6}$$

Now, differentiating $\Psi(I_x, I_y)$ with respect to β and evaluating it at $(I_x, I_y) = (\widehat{I}_x^*, \widehat{I}_y^*)$ yields

$$\begin{aligned} \frac{\partial \Psi}{\partial \beta} = \quad & \left[-\frac{dD_x(\widehat{I}_x^*)}{d\widehat{I}_x^*} + \delta(1-\beta) \frac{dP^H(\widehat{I}_x^*)}{d\widehat{I}_x^*}(x^H - x^L) \right] \frac{\partial \widehat{I}_x^*}{\partial \beta} \\ & + \left[-\frac{dD_y(\widehat{I}_y^*)}{d\widehat{I}_y^*} + \delta(1-\beta) \frac{dQ^H(\widehat{I}_y^*)}{d\widehat{I}_y^*}\zeta(y^H - y^L)z \right] \frac{\partial \widehat{I}_y^*}{\partial \beta}. \end{aligned} \tag{B7}$$

[20] Even though the principal can set w_1^L to be arbitrarily negative in the absence of limited liability, she must then increase V_2^m to satisfy (A3). Hence, an increase in β does not always lead to an increase in the principal's utility $\Psi(I_x, I_y)$ under the short-term wage contract even without limited liability constraints.

Given Assumptions 1.1–1.3 and repeating a similar procedure used in deriving (A9), it follows from (B4) and (B5) that $\frac{\partial \widehat{I}_x^*}{\partial \beta} > 0$ and $\frac{\partial \widehat{I}_y^*}{\partial \beta} > 0$. Because the principal's utility in period 1 under the long-term wage contract is independent of β, it is found from (B4), (B5), and (B7) that $\frac{\partial \Psi}{\partial \beta} > 0$ (or $\frac{\partial \Psi}{\partial \beta} < 0$) if $\beta < \frac{1}{2}$ (or $\beta > \frac{1}{2}$), that is, if the manager's bargaining power is smaller (or larger) than the principal's one. This implies that if $\beta < \frac{1}{2}$ (or $\beta > \frac{1}{2}$), the short-term wage contract is more (or less) likely to be preferred as β is larger. ∎

C. Proof of Proposition 3

I begin with the case of the limited liability constraint of type (ii). When $\zeta = 0$ so that $I_y^* = I_y^{**} = 0$, I can prove that the principal's utility is larger under the long-term wage contract than under the short-term wage contract. Indeed, setting $w_2^L = \frac{1}{2}x^L > 0$, $w^H = \frac{1}{2}x^H > 0$, and

$$w_1^L = D_x(I_x^*) - \frac{\delta}{2} \sum_{j=H,L} P^j(I_x^*)x^j + u.$$

I show that under the long-term wage contract, the manager chooses I_x^* (see (A2a) in Appendix A) and the principal obtains the same utility as she does under the short-term wage contract (see (A4), (A7), and (A8) in Appendix A). In fact, under the long-term wage contract, the principal can make the wage difference, $w_2^H - w_2^L$, larger than $\frac{1}{2}(x^H - x^L)$ so that the level of I_y chosen by the manager becomes larger than I_y^*. The principal can also keep the manager's expected wage constant. Hence, her gain is larger under the long-term wage contract than under the short-term wage contract.

When $\zeta > 0$, Proposition 1.3 still holds with smaller $\bar{\zeta}$. This is because if I consider the short-term wage contract, the principal obtains the same gain as in the absence of the limited liability constraints. Alternatively, if I consider the long-term wage contract, the principal's gain is smaller under the limited liability constraint.

For the limited liability constraint of type (i), if (8) is satisfied, the same results are obtained using the same argument as that of the limited liability constraint of type (ii). ∎

D. Proof of Proposition 4

A Short-term Wage Contract

The bargaining problem in period two is as follows: for a given (I_x, I_y),

$$\max_{w_2^H, w_2^L} \left\{ \sum_{j=H,L} P^j(I_x)(x^j - w_2^j) - z + \sum_{i=H,L} Q^i(I_y)\zeta y^i z \right\} \left\{ \sum_{j=H,L} P^j(I_x) U(w_2^j) \right\}.$$

Note that $w_2^H, w_2^L \geq 0$ is shown later. The first-order conditions with respect to w_2^H and w_2^L are then as follows:

$$\sum_{j=H,L} P^j(I_x)U(w_2^j) = U'(w_2^i) \left[\sum_{j=H,L} P^j(I_x)(x^j - w_2^j) - z + \sum_{i=H,L} Q^i(I_y)\zeta y^i z \right],$$

for $i = H, L$. This yields

$$w_2^H = w_2^L.$$

That is, a fixed wage is offered. On the other hand, it follows from the above first-order condition with $U'(w) = (1-\rho)w^{-\rho}$ that

$$w_2 = w_2^H = w_2^L = (1-\rho) \left[\sum_{j=H,L} P^j(I_x)x^j - z + \sum_{i=H,L} Q^i(I_y)\zeta y^i z \right] \geq 0.$$

Thus, the utility for the manager in the second period, denoted by $V_2^m(I_x, I_y, \rho, \zeta)$, is equal to $w_2^{1-\rho}$. Note that $V_2^m(I_x, I_y, 0, \zeta)$ is equal to the utility for the risk-neutral manager in the second period obtained in Section 2. The utility for the principal is then obtained as follows:

$$V_2^p(I_x, I_y, \rho, \zeta) = \rho \left[\sum_{j=H,L} P^j(I_x)x^j - z + \sum_{i=H,L} Q^i(I_y)\zeta y^i z \right].$$

In the first period, the agent chooses I_x and I_y so as to satisfy the incentive compatibility constraint:

$$\max_{I_x, I_y} \left(w_1^L\right)^{1-\rho} - D_x(I_x) - D_y(I_y) + \delta \left\{ (1-\rho) \left[\sum_{j=H,L} P^j(I_x)x^j - z + \sum_{i=H,L} Q^i(I_y)\zeta y^i z \right] \right\}^{1-\rho}. \tag{D1}$$

The first-order conditions yield

$$\frac{dD_x(I_x)}{dI_x} = \delta(1-\rho)^2 \frac{dP^H(I_x)}{dI_x}(x^H - x^L) \left[(1-\rho) \left\{ \sum_{j=H,L} P^j(I_x)x^j - z + \sum_{i=H,L} Q^i(I_y)\zeta y^i z \right\} \right]^{-\rho}, \tag{D2a}$$

and

$$\frac{dD_y(I_y)}{dI_y}=\delta\zeta(1-\rho)^2\frac{dQ^H(I_y)}{dI_y}(y^H-y^L)z\left\{(1-\rho)\left[\sum_{j=H,L}P^j(I_x)x^j-z+\sum_{i=H,L}Q^i(I_y)\zeta y^iz\right]\right\}^{-\rho}. \tag{D2b}$$

Note that by Assumption 1, the second-order conditions are satisfied and the solutions of the above equations, denoted $I_x^*(\rho,\zeta)$ and $I_y^*(\rho,\zeta)$, are continuous functions of (ρ,ζ). On the other hand, by the individual rationality constraint, the principal must set

$$w_1^L=D_x(I_x^*(\rho,\zeta))+D_y(I_y^*(\rho,\zeta))-\delta V_2^m(I_x^*(\rho,\zeta),I_y^*(\rho,\zeta))+u. \tag{D3}$$

Then, the principal's value,

$$x^L-w_1^L-(1-\zeta y^L)z+\delta V_2^p(I_x^*(\rho,\zeta),I_y^*(\rho,\zeta)), \tag{D4}$$

is a continuous function of (ρ,ζ), because I_x^* and I_y^* are continuous functions of (ρ,ζ). Note that w_1^L is positive for ρ sufficiently close to 0, because $I_x^*(0,\zeta)$ and $I_y^*(0,\zeta)$ are the investments for a risk-neutral manager and wages are then positive. That is, the limited liability constraint is satisfied. ∎

A Long-term wage contract

The principal's problem is as follows:

$$\max_{w_1^L\geq 0,I_x,I_y,w_2^H\geq 0,w_2^L\geq 0} x^L-w_1^L-(1-\zeta y^L)z+\delta\left(\sum_{j=H,L}P^j(I_x)(x^j-w_2^j)-z+\sum_{i=H,L}Q^i(I_y)\zeta y^iz\right), \tag{D5}$$

$$\text{s.t.}\quad (w_1^L)^{1-\rho}-D_x(I_x)-D_y(I_y)+\delta\sum_{j=H,L}P^j(I_x)w_2^j)^{1-\rho}\geq u, \tag{D6}$$

$$(w_1^L)^{1-\rho}-D_x(I_x)-D_y(I_y)+\delta\sum_{j=H,L}P^j(I_x)(w_2^j)^{1-\rho} \tag{D7}$$
$$\geq (w_1^L)^{1-\rho}-D_x(I_x')-D_y(I_y')+\delta\sum_{j=H,L}P^j(I_x')(w_2^j)^{1-\rho},{}^\forall I_x',I_y'.$$

As the principal has no incentive scheme for I_y, it has to be zero, that is, $I_y=0$.

Below, I follow Berge's Maximum Theorem (see Hildenbrand, 1974) and Adachi-Sato and Kamiya (2013) to show that the value of the above problem is a continuous function of ρ. Let

$B = D_x(I_x^{**}+1)+u+1$, where I_x^{**} is the investment level that maximizes the expected total net payoff generated by the firm without considering social costs in the case of a risk-neutral manager. Then, I can restrict the domain of investments and wages in the compact set $\Omega = \{(I_x, w_1^L, w_2^H, w_2^L) \mid 0 \le I_x \le I_x^{**}+1,\ 0 \le (w_1^L)^{1-\rho}, \delta(w_2^H)^{1-\rho}, \delta(w_2^L)^{1-\rho} \le B\}$.

I now prove that the feasible set in the above problem is a continuous correspondence of ρ. Let $\Gamma(\rho)$ be the feasible set of the principal's problem, i.e., the set of $(I_x, w_1^L, w_2^H, w_2^L)$ satisfying (D6) and (D7). Let $\Pi(\rho) = \Gamma(\rho) \cap \Omega$. The upper hemicontinuity of $\Pi(\rho)$ follows from the continuity of the functions in the constraints. The lower hemicontinuity of $\Pi(\rho)$ can be obtained as follows. Note that by the strict concavity of P^H and the strict convexity of D_x, the optimal I_x in (D7) is a continuous function of (ρ, w_2^H, w_2^L), denoted by $I_x(\rho, w_2^H, w_2^L)$. For $\hat{\rho} \in [0,1)$, let $(\widehat{I}_x, \hat{w}_1^L, \hat{w}_2^H, \hat{w}_2^L) \in \Pi(\hat{\rho})$ and $\rho^k \in [0,1), k = 1,2\ldots$, be a sequence converging to $\hat{\rho}$. If $(\hat{w}_1^L)^{1-\rho}, \delta(\hat{w}_2^H)^{1-\rho}$, and $\delta(\hat{w}_2^L)^{1-\rho}$ are larger than 0 and smaller than B, it is easy to find a subsequence $(w_1^{Lk}, w_2^{Hk}, w_2^{Lk}), k = 1,2\ldots$, satisfying (D6) with $\rho = \rho^k$ and $I_x = I_x(\rho^k, w_2^{Hk}, w_2^{Lk})$, and converging to $(\hat{w}_1^L, \hat{w}_2^H, \hat{w}_2^L)$. Suppose that some of $(\hat{w}_1^L)^{1-\rho}$,$\delta(\hat{w}_2^H)^{1-\rho}$, and $\delta(\hat{w}_2^L)^{1-\rho}$ are equal to 0 or to B. If all such wages are equal to zero, then (D6) is not satisfied because $u > 0$. Thus, some of these wages must be positive. If at least such positive one is less than B, it is easy to find a subsequence $(w_1^{Lk}, w_2^{Hk}, w_2^{Lk}), k = 1,2\ldots$, satisfying (D6) with $\rho = \rho^k$ and $I_x = I_x(\rho^k, w_2^{Hk}, w_2^{Lk})$, and converging to $(\hat{w}_1^L, \hat{w}_2^H, \hat{w}_2^L)$. If all are equal to B, then (D6) is satisfied with strict inequality, and thus it is possible to find $(w_1^{Lk}, w_2^{Hk}, w_2^{Lk})$ satisfying (D6) with $\rho = \rho^k$ and $I_x = I_x(\rho^k, w_2^{Hk}, w_2^{Lk})$, and converging to $(\hat{w}_1^L, \hat{w}_2^H, \hat{w}_2^L)$. It is clear that $I_x(\rho^k, w_2^{Hk}, w_2^{Lk})$ converges to $\widehat{I}_x$. Then, Π is a lower hemicontinuous correspondence. Consequently, Π is a continuous correspondence of ρ.

All together with the continuity of the objective function, the continuity of the maximum value of problem (D5) in ρ follows from Berge's Maximum Theorem. Moreover, because $I_y = 0$ always holds, the maximum value for the principal under the long-term wage contract is a continuous function of (ρ, ζ). ∎

A Comparison of Two Types of Contract As shown above, the values for the principal under the short-term wage contract and the long-term contract are continuous functions of (ρ, ζ), and coincide with those in the case of a risk-neutral manager at $\rho = 0$. Therefore, for $^{\exists}\bar{\rho} \in (0,1)$, I verify that the same property as in the case of a risk-neutral manager holds for $^{\forall}\rho \in (0, \bar{\rho}]$. ∎