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*Research Note*

# Corporate Social Responsibility and Labor-Managed Duopoly with Wage Rise as Strategic Commitment

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## Abstract

This paper investigates a duopoly game model in which two labor-managed firms compete in quantities. The game proceeds as follows. In the first stage, each labor-managed firm independently and simultaneously chooses the corporate social responsibility (CSR) level. In the second stage, each labor-managed firm independently and simultaneously chooses whether or not to offer the wage-rise contract policy (WRCP) as a strategic commitment device. If a labor-managed firm offers WRCP, it decides an output level and a wage premium rate. In addition, the labor-managed firm agrees to pay each employee a wage premium uniformly, provided that it actually produces more than the chosen output. At the end of the game, each labor-managed firm independently and simultaneously chooses an actual output. First, the paper examines the reaction functions of labor-managed firms in the model and shows that the reaction functions of labor-managed firms are upward-sloping. Next, this paper discusses the equilibrium of the model and shows that there is an equilibrium in which each labor-managed firm does not use CSR as a business strategy.

**Keywords:** Corporate social responsibility, Cournot model, Labor-managed firm, Reaction function, Wage-rise contract.

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## Introduction

Labor-managed firms are enterprises where workers actively participate in company management and decision-making processes. In contrast to conventional firms, labor-managed firms prioritize maximizing profit per worker and are characterized by three fundamental aspects: 1) participation of workers (members) in the decision-making of the company, 2) profit distribution to workers, and 3) corporate governance by workers (Putterman, 2008). Labor-managed firms are currently observed in most countries around the world and are empirically examined (see, e.g., Marshall, 2003; Podivinsky & Stewart, 2007; Maietta & Sena, 2008; Fakhfakh et al., 2012; De Reuver et al., 2021; Kotliarov, 2022; McLeod, 2022).

Therefore, this paper considers a theoretical model where labor-managed firms compete with each other. Since the pioneering work by Ward (1958), there have been many theoretical models that incorporate labor-managed firms (see, e.g., Sertel, 1991; Okuguchi, 1993; Zhang, 1993; Kamshad, 1997; Lambertini & Rossini, 1998; Lambertini, 2001; Ireland, 2003; Kihlstrom & Laffont, 2002; Goel & Haruna, 2007; Cuccia & Cellini, 2009; Ohnishi, 2009, 2010; Luo, 2013; Kalashnikov et al., 2015; Ho et al., 2021; Kalashnykova et al., 2022).

The analysis by Ireland (2003) compares the behavior of profit-maximizing capitalist firms with that of labor-managed firms in price-setting oligopoly markets. Ireland demonstrates that labor-managed firms price lower than profit-maximizing capitalist firms. Okuguchi (1993) investigates two models of a duopoly with product differentiation, in one of which two firms' strategies are outputs (labor-managed Cournot duopoly), and prices become strategic variables in the other (labor-managed Bertrand duopoly). He shows that if two firms are symmetric, leadership is less advantageous than followership in both Cournot-Stackelberg and Bertrand-Stackelberg duopolies with product differentiation. Lambertini (2001) investigates a spatial differentiation duopoly model and demonstrates that if the firms are labor-managed, there is a symmetric subgame perfect Nash equilibrium with firms located at the first and third quartiles, provided that the setup cost is low enough.

Goel & Haruna (2007) use a two-stage duopoly game model of cost-reducing R&D investment with spillovers and investigate strategic interactions between labor-managed firms. They demonstrate that the effects of changes in research spillovers on employment (output) depend on the nature of the underlying production technology. Luo (2013) develops a two-stage game model based on cost-reducing R&D with spillover and absorptive capacity. Luo examines the strategic interactions of output, R&D investment, and social welfare in the mixed duopoly with a labor-managed and a profit-maximizing firm and suggests that the labor-managed firm employs fewer workers and produces less output while investing more in R&D than the profit-maximizing firm. Ho et al. (2021) analyze the effect of R&D rivalry between a profit-maximizing capitalist firm and a labor-managed firm in an international market and show that investing more in R&D activities may benefit the labor-managed firm by increasing its share in the international market and decreasing the market share of the profit-maximization capitalist firm.

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Kalashnikov et al. (2015) present a model of a mixed duopoly with a labor-managed firm and a profit-maximizing capitalist firm and examine the existence and uniqueness of the consistent conjectural variations equilibrium in this model. Kalashnikov et al. conclude that the consistent conjectural variations equilibrium exists and is unique under certain conditions. Ohnishi (2010) presents a price-setting oligopoly model in which labor-managed firms can offer retroactive most-favored-customer policies as a strategic instrument and shows the effects of the retroactive most-favored-customer policy. Ohnishi concludes that the retroactive most-favored-customer policy helps sellers cooperate because it enables both firms to offer higher prices and to enjoy higher payoffs and facilitates collusion between firms. Kalashnykova et al. (2022) present an oligopoly model within the framework of consistent conjectural variations where a labor-managed firm competes with profit-maximizing capitalist firms. Production costs are considered quadratic functions, and consumer demand is considered a discontinuous function. Kalashnykova et al. show the existence and uniqueness of the consistent conjectural variations equilibrium in this model.

What business strategies are effective for labor-managed firms to maximize their objective functions? Therefore, this paper investigates whether corporate social responsibility (CSR) as a business strategy is beneficial for labor-managed firms. There are many theoretical analyses of CSR (see, e.g., Goering, 2007; Lambertini & Tampieri, 2012; Kopel & Brand, 2012; Kopel et al., 2014; Xu, 2014; Cracau, 2015; Kopel, 2015; Fanti & Buccella, 2016, 2018; Flores & García, 2016; Matsumura & Ogawa, 2016; Ouattara, 2017; Planer-Friedrich & Sahm, 2018; Han, 2019; Ohnishi, 2022b, 2023; Zhu et al., 2023).

The theoretical analysis by Kopel & Brand (2012) examines the managerial incentive contract when a profit-maximizing capitalist firm and a socially responsible firm compete in quantities and demonstrates that there is a subgame perfect equilibrium where both firms hire managers. Kopel et al. (2014) consider a mixed oligopoly model where profit-maximizing capitalist firms and socially responsible firms compete in a Cournot fashion and use an evolutionary setting to examine the endogenous choice of the proper objective of firms that pursue non-profit motives. It is then shown that socially responsible firms have higher market shares and profits than their profit-maximizing rivals. Fanti & Buccella (2016) consider a quantity-setting duopoly model with network goods and show that if both firms adopt CSR rules, the equilibrium profits that they may obtain are higher than they are profit-seeking. Ouattara (2017) studies the impact of CSR on privatization in a mixed duopoly model consisting of one state-owned public firm and one socially responsible firm and demonstrates that the government should decrease the degree of privatization if the level of CSR increases. Han (2019) considers a quantity-setting mixed oligopoly model to examine the effects of firms' CSR activities on the privatization of a state-owned firm and demonstrates that the optimal degree of privatization decreases with the firms' CSR activities. Ohnishi (2022b) considers a three-stage oligopoly game model in which labor-managed firms compete in a Cournot fashion. In the first stage, each labor-managed firm simultaneously chooses the level of CSR. In the second stage, each labor-managed firm simultaneously chooses whether or not to offer lifetime employment as a strategic commitment device. In the third stage, each labor-managed firm simultaneously chooses an actual output level. It is then shown that the reaction functions of labor-managed firms have both downward and upward cases. Zhu et al. (2023) investigate the

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impact of incentives on CSR operations in a game-theoretical model with two firms engaged in quantity competition. Zhu et al. show that firms are more likely to exert more CSR effort when they face a high violation exposure risk, but a high cost premium discourages them from doing so.

Furthermore, the paper examines the effectiveness of the wage-rise contract policy (WRCP) as a strategic device. Ohnishi (2007) examines a two-stage quantity-setting game model with two labor-managed firms. At stage one, each labor-managed firm independently and simultaneously decides whether or not to offer WRCP. At stage two, each labor-managed firm independently and simultaneously chooses its actual output. It is then shown that there is an equilibrium solution in which at least one labor-managed firm offers WRCP. Ohnishi (2012) examines the behaviors of a profit-maximizing firm and a labor-managed firm in a two-stage quantity-setting model with WRCP as a strategic commitment and shows that there is a unique equilibrium that coincides with the Stackelberg solution where the profit-maximizing firm is the leader, and the labor-managed firm is the follower. Ohnishi (2015) examines a three-stage duopoly model where a state-owned firm and a labor-managed firm can sequentially offer WRCP as a strategic device before competing in quantities. The following three stages are considered. In the first stage, the state-owned firm chooses whether or not to offer WRCP. In the second stage, the labor-managed firm decides whether or not to offer WRCP. In the third stage, the firms set their outputs independently and simultaneously. It is then shown that there is an equilibrium solution where neither firm offers WRCP. Ohnishi (2022a) investigates a two-stage Cournot duopoly model with a nonlinear demand function where a socially concerned firm competes with a profit-maximizing firm and shows that WRCP as a strategic commitment device may be profitable for both firms.

In this paper, we consider a three-stage duopoly game model in which two labor-managed firms compete in quantities. In the first stage, each labor-managed firm independently and simultaneously chooses the level of CSR. In the second stage, each labor-managed firm independently and simultaneously chooses whether to offer WRCP as a strategic commitment device. In the third stage, each labor-managed firm independently and simultaneously chooses an actual output level. We analyze whether CSR and WRCP as strategic devices are beneficial for labor-managed firms. To the best of the author's knowledge, there is no existing research that addresses this particular economic situation. We first present the reaction functions of labor-managed firms in the model. Next, we discuss the equilibrium outcome of the model.

## Model

There are two labor-managed firms, firm 1 and firm 2. Both firms produce perfectly substitutable commodities. There is no possibility of entry or exit. For the remainder of this paper, subscripts 1 and 2 represent firm 1 and firm 2, respectively. Furthermore, when $i$ and $j$ are used to refer to firms in an expression, they represent 1 and 2 with $i \neq j$. The market price is determined by the following linear inverse demand function: $P(Q) = 10 - Q$, where $Q = \sum_{i=1}^{2} q_i$ denotes the total output produced by the firms.

Firm $i$'s profit per worker is given as

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$$\omega_i = \frac{\left(10 - Q^2\right) q_i - m_i q_i - f_i}{l_i\left(q_i\right)}, \tag{1}$$

where $m_i$ denotes firm $i$'s total cost for each unit of output, $f_i$ is firm $i$'s fixed cost, and $l_i(q_i)$ is the number of workers in firm $i$. We assume that $m_i = f_i = 1$. In addition, we assume that

$$l_i\left(q_i\right) = q_i^2. \tag{2}$$

Therefore, the equation (1) changes as follows:

$$\omega_i = \frac{\left(10 - Q^2\right) q_i - q_i - 1}{q_i^2}. \tag{3}$$

The game proceeds as follows. In the first stage, each firm independently and simultaneously chooses $\theta_i \in [0,1]$, which represents the percentage of consumer surplus:

$$CS = \int_0^Q \left(10 - X^2\right) dX - \left(10 - Q^2\right) Q. \tag{4}$$

In the second stage, each firm independently and simultaneously decides whether to offer WRCP as a strategic commitment device. If firm $i$ offers WRCP, it decides a wage premium rate $t_i \in (0, \infty)$ and an output level $q_i^* \in [0, \infty)$. Furthermore, firm $i$ agrees to pay a wage premium to each employee, provided that it actually produces more than $q_i^*$. At the end of the game, each firm independently and simultaneously chooses an actual output $q_i \in [0, \infty)$.

Hence, the CSR objective function is given by

$$\Omega_i = \begin{cases} \theta_i \left[ \int_0^Q \left(10 - X^2\right) dX - \left(10 - Q^2\right) Q \right] + \dfrac{\left(10 - Q^2\right) q_i - q_i - 1}{q_i^2} & \text{if } q_i \le q_i^*, \\ \theta_i \left[ \int_0^Q \left(10 - X^2\right) dX - \left(10 - Q^2\right) Q \right] + \dfrac{\left(10 - Q^2\right) q_i - q_i - \left(q_i - q_i^*\right) t_i - 1}{q_i^2} & \text{if } q_i \ge q_i^*. \end{cases} \tag{5}$$

In this paper, we use subgame perfection as our equilibrium concept.

## Reaction Functions

Before presenting the equilibrium outcome of the model, we derive firm $i$'s best reaction function from (5). If firm $i$ produces $q_i < q_i^*$, then its reaction function is defined by

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$$R_i(q_j)=\arg\max_{q_i\geq 0}\left\{\theta_i\left[\int_0^Q\left(10-X^2\right)dX-\left(10-Q^2\right)Q\right]+\frac{\left(10-Q^2\right)q_i-q_i-1}{q_i^2}\right\}, \tag{6}$$

On the other hand, if firm $i$ wishes to produce $q_i > q_i^*$, then its reaction function is defined by

$$\hat{R}_i(q_j) = \arg\max_{q_i\geq 0}\left\{\theta_i\left[\int_0^Q\left(10-X^2\right)dX-\left(10-Q^2\right)Q\right]+\frac{\left(10-Q^2\right)q_i-q_i-\left(q_i-q_i^*\right)t_i-1}{q_i^2}\right\}. \tag{7}$$

Hence, if firm $i$ selects $q_i^*$ and offers WRCP, then its best reply is shown as follows:

$$R_i^W(q_j)=\begin{cases}R_i(q_j) & \text{if } q_i<q_i^*,\\ q_i^* & \text{if } q_i=q_i^*,\\ \hat{R}_i(q_j) & \text{if } q_i>q_i^*.\end{cases} \tag{8}$$

Firm $i$ maximizes $\Omega_i$ with respect to $q_i$. Therefore, the first-order condition for firm $i$ when $q_i < q_i^*$ is

$$2\theta_i q_i^3\left(q_i+q_j\right)^2-q_i\left(9+q_i^2-q_j^2\right)+2=0, \tag{9}$$

and the second-order condition is

$$2\theta_i q_i^2\left(q_i+q_j\right)\left(5q_i+3q_j\right)-3q_i^2+q_j^2-9<0. \tag{10}$$

On the other hand, the first-order condition for firm $i$ when $q_i > q_i^*$ is

$$2\theta_i q_i^3\left(q_i+q_j\right)^2-q_i\left(9+q_i^2-q_j^2-t_i\right)-2\left(t_i q_i^*-1\right)=0, \tag{11}$$

and the second-order condition is

$$2\theta_i q_i^2\left(q_i+q_j\right)\left(5q_i+3q_j\right)-3q_i^2+q_j^2-9+t_i<0. \tag{12}$$

Hence, we have

$$R_i'(q_j)=-\frac{4\theta_i q_i^3\left(q_i+q_j\right)+2q_iq_j}{2\theta_i q_i^2\left(q_i+q_j\right)\left(5q_i+3q_j\right)-3q_i^2+q_j^2-9} \tag{13}$$

and

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$$\hat{R}_i'(q_j) = -\frac{4\theta_i q_i^3\left(q_i+q_j\right)+2q_iq_j}{2\theta_i q_i^2\left(q_i+q_j\right)\left(5q_i+3q_j\right)-3q_i^2+q_j^2-9+t_i}. \quad (14)$$

We notice that the numerators of (13) and (14) are positive. We also notice that the denominator of (13) is smaller than that of (14).

We can now present the following proposition.

PROPOSITION 1: (i) *Both* $R_i(q_j)$ *and* $\hat{R}_i(q_j)$ *are upward-sloping.* (ii) *The slope of* $\hat{R}_i(q_j)$ *is smoother than that of* $R_i(q_j)$.

In the next section, we present the equilibrium of the model.

## Equilibrium

We begin by proving the following three lemmas.

LEMMA 1: *If firm i offers WRCP, then in equilibrium,* $q_i = q_i^*$.

PROOF: First, consider the possibility that $q_i > q_i^*$ is in equilibrium. From (5), firm *i*'s objective function is

$$\Omega_i = \theta_i\left[\int_0^Q\left(10-X^2\right)dX-\left(10-Q^2\right)Q\right]+\frac{\left(10-Q^2\right)q_i-q_i-\left(q_i-q_i^*\right)t_i-1}{q_i^2}.$$

Here, firm *i* can increase its objective function by increasing $q_i^*$, and the equilibrium point does not change in $q_i \geq q_i^*$. Hence, $q_i > q_i^*$ does not result in an equilibrium.

Next, consider the possibility that $q_i < q_i^*$ is in equilibrium. From (5), we see that it is impossible for firm *i* to change its output level because such a strategy is not credible. Therefore, WRCP does not function as a strategic commitment device. Q.E.D.

LEMMA 2: *Firm i's optimal output level is smaller when it offers WRCP than when it does not.*

PROOF: From (5), we see that WRCP will never decrease the marginal cost for firm *i*. When the marginal cost of production is 1, the first-order condition for firm *i* is (9). On the other hand, when the marginal cost of production is $1 + t_i$, the first-order condition for firm *i* is (11). Here, $t_i$ is positive. Hence, to satisfy (11), $2\theta_i q_i^3\left(q_i+q_j\right)^2 - q_i\left(9+q_i^2-q_j^2\right)+2$ must be positive. Lemma 1 shows that firm *i*'s optimal output when it offers WRCP coincides with $q_i^*$. Thus, firm *i*'s optimal output is smaller when its marginal cost is $1 + t_i$ than when its marginal cost is 1. Q.E.D.

Lemmas 1 and 2 provide characterizations of WRCP as a strategic commitment device. Lemma 1 indicates that in equilibrium firm *i* does not pay wage premiums to employees. Lemma 2 says that the adoption of WRCP by firm *i* increases its marginal cost of

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production and decreases its optimal output.

LEMMA 3: *If the level of $\theta_i$ is increased, the value of $\omega_i$ is decreased.*

PROOF: The first-order condition for firm $i$, when its marginal cost is 1, is (9), and the first-order condition, when its marginal cost is $1 + t_i$, is (11). From (9) and (11), we see that if the level of $\theta_i$ is increased, $2\theta_i q_i^3 \left(q_i + q_j\right)^2$ is increased. Thus, to satisfy (9) and (11), $-q_i\left(9 + q_i^2 - q_j^2\right) + 2$ and $-q_i\left(9 + q_i^2 - q_j^2 - t_i\right) + 2(t_i q_i^* - 1)$ must be decreased. Q.E.D.

We now discuss the equilibrium solution of the model. We first consider the case where there is neither WRCP nor CSR. This case is a standard Cournot game, and a one-shot Nash game determines the equilibrium. Therefore, the optimal solution of this case is as follows: $q_i^N = 2/9\,, \omega_i^N \approx 19.3611$.

Second, we consider the case with no CSR. At stage one, each firm decides to offer WRCP. At stage two, the solution is decided in a Cournot fashion. Firm $i$'s optimal output level is lower when it offers WRCP than when it does not (Lemma 2). Therefore, the optimal solution of this case is as follows: $q_i^W \approx 0.2180, \omega_i^W \approx 19.3704$.

Third, we consider the case with no WRCP. In the first stage, each firm independently and simultaneously chooses the level of $\theta_i$. In the second stage, each firm independently and simultaneously chooses an actual output. Lemma 3 shows that if the level of $\theta_i$ is increased, the value of $\omega_i$ is decreased. Therefore, if $\theta_i = 1/2$, then $q_i^C \approx 0.2225, \omega_i^C \approx 19.3601$.

Fourth, we consider the case with WRCP and CSR. At stage one, each firm independently and simultaneously chooses the level of $\theta_i$. At stage two, each firm decides to offer WRCP. At stage three, the solution is decided in a Cournot fashion. Firm $i$'s optimal output is smaller when it adopts WRCP than when it does not (Lemma 2). If the level of $\theta_i$ is increased, the value of $\omega_i$ is decreased (Lemma 3). Hence, $\omega_i^{WC}$ is smaller than $\omega_i^W$.

The main result of this paper is presented in the following proposition.

PROPOSITION 2: *In the labor-managed duopoly model, there exists an equilibrium in which each firm adopts WRCP while not using CSR.*

## Concluding Remarks

We have examined a quantity-setting duopoly model in which two labor-managed firms compete with each other. Each labor-managed firm can choose the level of CSR. First, we have shown that the Cournot reaction functions of labor-managed firms are upward-sloping. Next, we have shown that there is an equilibrium in which each labor-managed firm offers WRCP but does not use CSR. Since WRCP specifies a higher marginal cost of production, the adoption of WRCP by a labor-managed firm decreases its optimal output. Therefore, labor-managed firms should behave less aggressively toward each other. Furthermore, we see that the introduction of WRCP as a strategic

device is beneficial for labor-managed firms.

This paper has focused on a straightforward labor-managed duopoly model. In the future, we will examine the following two extended models. Firstly, we have examined a quantity-setting model. However, price rather than quantity is a strategic choice variable for inter-business competition. Therefore, in the near future, we will examine an oligopoly game model with CSR and WRCP as strategic devices where labor-managed firms compete in a Bertrand fashion and will compare the results of this paper with those of the Bertrand game model. Secondly, we have examined a one-shot duopoly game. However, in reality, most firms face long-run competition. Therefore, we will examine the equilibrium of a repeated oligopoly model with CSR and WRCP as strategic devices where labor-managed firms compete with each other.

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