WAGE-RISE CONTRACT AND LABOUR-MANAGED COURNOT OLIGOPOLY WITH COMPLEMENTARY GOODS

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ABSTRACT

This paper considers a quantity-setting oligopoly model with complementary goods where labour-managed firms are allowed to offer wage-rise contracts as a strategic commitment. The following two stages are considered. In the first stage, each firm independently decides whether or not to adopt a wage-rise contract as a strategic commitment device. In the second stage, each firm independently chooses and sells its actual output. The paper analyses the equilibrium of the labour-managed oligopoly model.

Keywords: Cournot competition, Labour-managed oligopoly, Wage-rise contract, Complementary goods

JEL Classification: C72, D43, L31

Introduction

The oldest surviving labour-managed firms in Italy and the United Kingdom were established in the nineteenth century (Bonin et al. 1993). After the Second World War, the right to manage the firm in the former Yugoslavia was, within the limits determined by law, in the hands of its employees (Furubotn and Pejovich 1970). From 1970s onwards, it is confirmed that labour-managed firms exist in

many industries and societies all over the world (Stephan 1982; Estrin 1985; Bonin et al. 1993; Novkovic and Sena 2007).Furthermore, in China, the market-oriented economic reform has given much greater autonomy to state and collective enterprises' managers to make investment, production and marketing decisions. Meng and Perkins (1998) find that the state and the collective sectors behave like labour-managed firms in their wage determination, while privatesectorsare pure profitmaximizers. Street et al. (2018) study how Mid South Building Supply (MSBS) survived the Great Recession during the late 2000s and early 2010s. MSBS is a 100% employee-owned company in the United States that supply residential building products. They find that employee-owned firms are more likely to survive recessions than other firms.

The first theoretical analysis of firm behaviour in the former Yugoslavia was done by Ward (1958). Since the seminal work by Ward (1958), a great many researchers have analysed the behaviour of labour-managed firms. For instance, Laffont and Moreaux (1985) study the welfare properties of free-entry Cournot equilibria in labour-managed market economies and demonstrate that Cournot equilibria are efficient provided that the market is sufficiently large. Okuguchi (1986) compares the Cournot and Bertrand equilibrium prices for the labour-managed oligopoly under product differentiation and demonstrates that the Cournot equilibrium prices are not lower than the Bertrand ones. Zhang (1993) uses the framework of Dixit (1980) and Bulow et al. (1985) and studies whether labour-managed firms can hold excess capacity to deter entry and whether they are more or less likely to do so than profit-maximizing firms under identical conditions. He demonstrates that it is more likely for labour-managed firms than for profit-maximizing firms to keep excess capacity to deter entry. Okuguchi (1993) examines two models of duopoly with product differentiation and with only labour-managed firms, in one of which two firms' strategies are outputs (labour-managed Cournot duopoly) and prices become strategic variables in the other (labour-managed Bertrand duopoly). He demonstrates that if two firms are symmetric, leadership is not as advantageous as followership in both labour-managed Cournot-Stackelberg and Bertrand-Stackelberg duopolies with product differentiation. Neary and Ulph (1997) study the relative profitability of labour-managed and capitalist firms in a mixed duopoly equilibrium and demonstrate that the labour-managed firm produces more than the capitalist firm when the stability condition is satisfied. Lambertini and Rossini (1998) analyse the behaviour of labour-managed firms in a two-stage Cournot duopoly model with capital strategic interaction and demonstrate that labour-managed firms choose their capital commitments according to the level of interest rate, unlike what usually happens when only profit-maximizing firms operate in the market. Lambertini (2001) considers a spatial differentiation duopoly model and

demonstrates that if both firms are labour-managed, there exists a (symmetric) subgame perfect equilibrium in pure strategies with firms located at the first and third quartiles, if and only if the setup cost is low enough. Ireland (2003) compares the behaviour of profit-maximizing firms with that of labour-managed firms in Bertrand oligopoly competition and shows that labour-managed firms price lower than profit-maximizing firms. In addition, Ohnishi (2007) uses a quantity-setting model with substitute goods where two labour-managed firms are allowed to offer wage-rise contracts as a strategic commitment and shows that there is an equilibrium in which at least one labour-managed firm adopts the contract. There are also many other related research works (see, for example, Hill and Waterson 1983; Stewart 1991; Cremer and Cremer 1992; Futagami and Okamura 1996; Kamshad 1997; Lambertini 1997; Cuccia and Cellini 2009; Ohnishi 2009, 2010; Luo 2013). These works investigate theoretical models of oligopoly competition with substitute goods.

We consider a situation where labour-managed firms produce complementary goods. The case of 'complementary goods' has many real-world examples such as bread and butter, coffee and sugar, salad and salad dressing, pencils and erasers, toothbrushes and toothpowder, black pens and red pens, suits and ties, and cars and petrol.

We examine a Cournot oligopoly model in which labour-managed firms produce complementary goods and can offer wage-rise contracts as a strategic commitment.[1] To the best of the author's knowledge, there is no previous work dealing with such economic situation.

The purpose of this study is to present the equilibrium of a Cournot oligopoly model with complementary goods where labour-managed firms are allowed to offer wage-rise contracts as a strategic device. We find that our results are quite different from the results obtained from the labour-managed Cournot oligopoly model with substitute goods.

The Model

Let us consider a market in which there are $n \geq 2$ labour-managed firms producing complementary goods. There is no possibility of entry or exit. The market is modelled by means of the following two-stage game. In the first stage, each labour-managed firm independently decides whether or not to adopt a wage-rise contract as a strategic commitment device. If labour-managed firm i

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[1] For details of wage-rise contracts as a strategic commitment, see Ohnishi (2003).

($i = 1, 2, \ldots, n$) dose so, then it chooses an output level $x_i^* \geq 0$ and a wage premium rate $t_i > 0$. In addition, labour-managed firm i agrees to pay each employee a wage premium uniformly if it actually produces more than x_i^*. In the second stage, each labour-managed firm independently chooses and sells its actual output $x_i > 0$. Therefore, firm i's income per worker is given by

$$
\psi_i = \begin{cases}
\dfrac{p_i(x_1, x_2, \ldots, x_n)x_i - r_i k_i(x_i) - f_i}{l_i(x_i)} & \text{if } x_i \leq x_i^*, \\[4mm]
\dfrac{p_i(x_1, x_2, \ldots, x_n)x_i - r_i k_i(x_i) - (x_i - x_i^*)t_i - f_i}{l^i(x^i)} & \text{if } x_i \geq x_i^*,
\end{cases}
\tag{1}
$$

where $p_i : \mathbb{R}_{++}^n \to \mathbb{R}_{++}$ denotes firm i's inverse demand function, $x_i \in (0, \infty)$ is firm i's quantity, $r_i \in (0, \infty)$ is firm i's unit cost of capital, $k_i : \mathbb{R}_{++} \to \mathbb{R}_{++}$ is firm i's capital input function, $f_i \in (0, \infty)$ is firm i's fixed cost, and $l_i : \mathbb{R}_{++} \to \mathbb{R}_{++}$ is firm i's labour input function.

We assume that there is a unique Cournot equilibrium and each firm's price, output and income per worker are positive in the equilibrium. In addition, the following assumptions are made.

Assumption 1: p_i *is twice continuously differentiable with bounded derivatives,* $\partial p_i / \partial x_i < 0$ *(downward-sloping demand), and* $\partial p_i / \partial x_j > 0$ *(complementary goods)* $(i, j = 1, 2, \ldots, n; i \neq j)$.

Assumption 2: $\left| \dfrac{\partial p_i}{\partial x_i} \right| > \sum\limits_{j \neq i} \left| \dfrac{\partial p_i}{\partial x_j} \right|$.

Assumption 3: $\dfrac{dk_i}{dx_i} > 0$ *and* $\dfrac{d^2 k_i}{dx_i^2} > 0$.

Assumption 4: $\dfrac{dl_i}{dx_i} > 0$ *and* $\dfrac{d^2 l_i}{dx_i^2} > 0$.

These are fairly standard assumptions in Cournot oligopoly games except complementary goods. Assumption 1 states that demand is downward-sloping.

Assumption 2 means that firm *i*'s own effects of quantity on demand exceed firm *j*'s cross effects. Throughout this paper, we use subgame perfection as an equilibrium concept.

Results

We begin by giving supplementary explanations of the model introduced in the previous section. We derive labour-managed firm *i*'s reaction functions in quantities from (1). If firm *i* does not offer a wage-rise contract, its reaction function is defined by

$$R_i(x_{-i}) = \arg \max_{x_i > 0} \left[\frac{p_i(x_1, x_2, ..., x_n)x_i - r_i k_i(x_i) - f_i}{l_i(x_i)} \right], \tag{2}$$

where $x_{-i} = (x_1, x_2, ..., x_{i-1}, x_{i+1}, ..., x_n)$. On the other hand, if firm *i* offers a wage-rise contract and produces $x_i \geq x_i^*$, its reaction function is defined by

$$R_i^*(x_{-i}) = \arg \max_{x_i > 0} \left[\frac{p_i(x_1, x_2, ..., x_n)x_i - r_i k_i(x_i) - (x_i - x_i^*)t_i - f_i}{l_i(x_i)} \right]. \tag{3}$$

Therefore, if firm *i* sets x_i^* and offers a wage-rise contract, its best response is as follows:

$$\hat{R}_i(x_{-i}) = \begin{cases} R_i(x_{-i}) & \text{if } x_i < x_i^*, \\ x_i^* & \text{if } x_i = x_i^*, \\ R_i^*(x_{-i}) & \text{if } x_i > x_i^*. \end{cases} \tag{4}$$

We now state the following lemma.

Lemma 1: Both $R_i(x_{-i})$ and $R_i^*(x_{-i})$ are downward sloping.

Proof: Firm *i*'s aim is to maximize income per worker with respect to its own output, given the other firms' output. The Cournot solution needs to satisfy the following conditions: If firm *i* does not offer a wage-rise contract as a strategic device, the first-order condition for income per worker maximization is

$$\left(\frac{\partial p_i}{\partial x_i} x_i + p_i - r_i \frac{dk_i}{dx_i} \right) l_i - \left(p_i x_i - r_i k_i - f_i \right) \frac{dl_i}{dx_i} = 0, \tag{5}$$

and the second-order condition is

$$\left(\frac{\partial^2 p_i}{\partial x_i \partial x_i} x_i + 2\frac{\partial p_i}{\partial x_i} - r_i \frac{d^2 k_i}{dx_i^2} \right) l_i - \left(p_i x_i - r_i k_i - f_i \right) \frac{d^2 l_i}{dx_i^2} < 0. \tag{6}$$

On the other hand, if firm i adopts a wage-rise contract as a strategic device and produces $x_i \geq x_i^*$, the first-order condition for income per worker maximization is

$$\left(\frac{\partial p_i}{\partial x_i} x_i + p_i - r_i \frac{dk_i}{dx_i} - t_i \right) l_i - \left(p_i x_i - r_i k_i - t_i x_i + t_i x_i^* - f_i \right) \frac{dl_i}{dx_i} = 0, \tag{7}$$

and the second-order condition is

$$\left(\frac{\partial^2 p_i}{\partial x_i \partial x_i} x_i + 2\frac{\partial p_i}{\partial x_i} - r_i \frac{d^2 k_i}{dx_i^2} \right) l_i - \left(p_i x_i - r_i k_i - t_i x_i + t_i x_i^* - f_i \right) \frac{d^2 l_i}{dx_i^2} < 0. \tag{8}$$

Moreover, we obtain

$$R_i'(x_{-i}) = -\frac{\dfrac{\partial^2 p_i}{\partial x_i \partial x_j} x_i l_i + \dfrac{\partial p_i}{\partial x_j}\left(l_i - x_i \dfrac{dl_i}{dx_i} \right)}{\left(\dfrac{\partial^2 p_i}{\partial x_i \partial x_i} x_i + 2\dfrac{\partial p_i}{\partial x_i} - r_i \dfrac{d^2 k_i}{dx_i^2} \right) l_i - \left(p_i x_i - r_i k_i - f_i \right)\dfrac{d^2 l_i}{dx_i^2}} \tag{9}$$

and

$$R_i^{*'}(x_{-i}) = -\frac{\dfrac{\partial^2 p_i}{\partial x_i \partial x_j} x_i l_i + \dfrac{\partial p_i}{\partial x_j}\left(l_i - x_i \dfrac{dl_i}{dx_i} \right)}{\left(\dfrac{\partial^2 p_i}{\partial x_i \partial x_i} x_i + 2\dfrac{\partial p_i}{\partial x_i} - r_i \dfrac{d^2 k_i}{dx_i^2} \right) l_i - \left(p_i x_i - r_i k_i - t_i x_i + t_i x_i^* - f_i \right)\dfrac{d^2 l_i}{dx_i^2}}. \tag{10}$$

Since $d^2 l_i/dx_i^2 > 0$, $l_i - x_i\left(dl_i/dx_i \right) < 0$, and hence $\left(\partial^2 p_i/\partial x_i \partial x_j \right) x_i l_i + \left(\partial p_i/\partial x_j \right)\left[l_i - x_i\left(dl_i/dx_i \right) \right]$ is positive. Q.E.D.

Secondly, we present the following lemmas, which provide characterizations of wage-rise contracts as a strategic commitment.

Lemma 2: If labour-managed firm i adopts a wage-rise contract and an equilibrium is achieved, then at equilibrium $x_i = x_i^*$.

Proof: First, consider the possibility that $x_i > x_i^*$ in equilibrium. From (1), firm i's income-per-worker is

$$\psi_i = \frac{p_i(x_1, x_2, ..., x_n)x_i - r_i k_i(x_i) - (x_i - x_i^*)t_i - f_i}{l^i(x^i)}.$$

Here, firm i can increase income per worker by increasing x_i^*, and the equilibrium solution does not change in $x_i \geq x_i^*$. Hence, $x_i > x_i^*$ does not result in an equilibrium.

Next, consider the possibility that $x_i < x_i^*$ in equilibrium. From (1), we see that it is impossible for firm i to change its output in equilibrium because such a strategy is not credible. That is, wage-rise contracts do not function as a strategic commitment devise. Q.E.D.

Lemma 3: Labour-managed firm i's optimal output is smaller when it adopts a wage-rise contract as a strategic commitment than when it does not.

Proof: From (1), we see that the contract will never decrease firm i's marginal cost of production. The first-order condition for firm i when its marginal cost is $r_i(\partial k_i/\partial x_i)$ is (5), and the first-order condition for firm i when its marginal cost of production is $r_i(\partial k_i/\partial x_i) + t_i$ is (7). Here, t_i is positive. Lemma 2 shows that firm i's equilibrium output when it adopts the contract coincides with x_i^*. To satisfy (7), $\left[\left(\partial^2 p_i/\partial x_i \partial x_i\right)x_i + 2\left(\partial p_i/\partial x_i\right) - r_i\left(d^2 k_i/dx_i^2\right)\right]l_i - \left(p_i x_i - r_i k_i - f_i\right)$ $\left(d^2 l_i/dx_i^2\right)$ needs to be positive. Thus, firm i's income-per-worker-maximizing output is smaller when its marginal cost is $r_i(\partial k_i/\partial x_i) + t_i$ than when its marginal cost is $r_i(\partial k_i/\partial x_i)$. Q.E.D.

We now present the equilibrium of the model introduced in the previous section. Both $R_i(x_{-i})$ and $R_i^*(x_{-i})$ slope downwards. If none of the firms provides a wage-rise contract to its workers, then the unique equilibrium occurs at the intersection of $R_1(x_{-1}), R_2(x_{-2}), ..., R_n(x_{-n})$. Therefore, if firm i chooses x_i^* and offers a wage-rise contract, then its marginal cost of production has a discontinuity at $x_i = x_i^*$. Lemma 3 states that the provision of a wage-rise contract by firm i decreases its

optimal quantity. The labour-managed firms choose quantities in a Cournot fashion.

We characterize the equilibrium of the model in the following proposition.

Proposition 1: *In the equilibrium of the labour-managed oligopoly model with complementary goods, none of the labour-managed firms offers a wage-rise contract as a strategic commitment.*

Proof: We consider firm i's Stackelberg leader output. If firm i is the Stackelberg leader, then it selects x_i and the other firms select their output level after observing x_i. When firm i is the Stackelberg leader, it maximizes $\psi(x_i, R_{-i}(x_i))$ with respect to x_i. Therefore, firm i's Stackelberg leader output satisfies the following first-order condition:

$$\left(\frac{\partial p_i}{\partial x_i} x_i + p_i - r_i \frac{dk_i}{dx_i}\right) l_i - \left(p_i x_i - r_i k_i - f_i\right)\frac{dl_i}{dx_i} + \frac{\partial p_i}{\partial x_i} x_i \frac{dR_{-i}}{dx_i} l_i = 0. \tag{11}$$

Here $\partial p_i/\partial x_i < 0$ (Assumption 1) and $dR_{-i}/dx_i < 0$ (Lemma 2). To satisfy (11), $\left[(\partial p_i/\partial x_i) x_i + p_i - r_i(dk_i/dx_i)\right] l_i - (p_i x_i - r_i k_i - f_i)(dl_i/dx_i)$ needs to be negative. Hence, each firm's Stackelberg leader output is higher than its Cournot output.

On the other hand, Lemma 3 states that firm i's optimal output is lower when it adopts a wage-rise contract as a strategic commitment than when it does not. In addition, Lemma 1 means that $R_1(x_{-1})$ is always downward sloping. Thus, the proposition is proved. Q.E.D.

Proposition 1 means that the equilibrium coincides with the Cournot solution with no wage-rise contracts.

Conclusions and Policy Implications

We have considered a quantity-setting oligopoly model in which labour-managed firms produce complementary goods and have shown that at equilibrium none of the labour-managed firms offers a wage-rise contract as a strategic commitment device. Ohnishi (2007) examines a labour-managed Cournot duopoly model with substitute goods and shows that at equilibrium at least one labour-managed firm offers a wage-rise contract as a strategic commitment. Therefore, we find that

our results are quite different from the results obtained from the labour-managed Cournot oligopoly model with substitute goods.

Finally, we would like to discuss policy implications for public administrations. The offer of a wage-rise contract by a firm increases its marginal cost of production and thereby decreases its optimal output. Moreover, the aggregate output level in the industry decreases in each case of substitute and complementary goods, and hence the price rises. The demand function is downward sloping, and thereforeboth consumer surplus and economic welfare are lower than in the simultaneously output choice game with no wage-rise contracts. It is indicated that a labour-managed firm unaggressively acting against the other labour-managed firms does not lead to economic welfare maximization. Therefore, we see that if labour-managed firms compete in quantity with each other, then governments that wish to improve economic welfare should not implement policies that increase firms' marginal costs of production. It follows from this that such governments should implement economic policies that decrease firms' marginal costs of production and promote competition among firms.

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