Lifetime employment contract and international mixed competition with state-owned domestic and labor-managed foreign firms

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May 2007

Abstract

This paper examines an international mixed model in which a state-owned welfare-maximizing domestic public firm competes with a labor-managed income-per-worker-maximizing foreign private firm. In the first stage, each firm independently decides whether or not to adopt lifetime employment. If a firm adopts lifetime employment, then it chooses an output level and enters into a lifetime employment contract with the number of employees necessary to achieve the output level. Hence, the firm's wage cost changes from a variable cost to a fixed cost. In the second stage, each firm independently chooses its actual output. The paper shows the equilibrium of the international mixed model.

Keywords: International mixed duopoly, State-owned domestic public firm, Labor-managed foreign private firm, Lifetime employment contract
JEL classification: F23, C72, D21, H42, L30

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1. Introduction

Following the pioneering work of Ward (1958), the analysis of labor-managed income-per-worker-maximizing firms has been studied by a lot of economists.[1] There are many excellent studies such as Svejnar (1982), Stewart (1991, 1992) Cremer and Crémer (1992), Delbono and Rossini (1992), Drago and Turnbull (1992), Futagami and Okamura (1996), Askildsen and Ireland (1993), Zhang (1993), Haruna (1996), Neary and Ulph (1997), Lambertini and Rossini (1998), and Lambertini (2001). Furthermore, the analysis of mixed market models that incorporate social-welfare-maximizing public firms has received increasing attention in recent year.[2] There are many excellent studies such as Cremer, Marchand, and Thisse (1991), Delbono and Rossini (1992), Delbono and Denicolò (1993), Nett (1994), Willner (1994), George and La Manna (1996), White (1996), Mujumdar and Pal (1998), Pal (1998), Poyago-Theotoky (1998), Wen and Sasaki (2001), Matsumura and Matsushima (2003), and so forth. These studies are models with domestic firms and do not include foreign firms.

Some literature includes foreign firms. Mai and Hwang (1989) examine the efficacy of export subsidization in an international economy with a labor-managed domestic firm and a profit-maximizing foreign firm. Okuguchi (1991) extends the analysis of Mai and Hwang (1989) assuming that labor-managed and profit-maximizing firms produce differentiated goods. Horowitz (1991) examines the effects of Cournot rivalry between a profit-maxmizing entrepreneurial firm and a dividend-maximizing labor-managed firm selling both in protected domestic markets and in an international market. Fjell and Pal (1996) extend the analysis to an international context by considering a mixed model where a state-owned public firm competes with both domestic and foreign private firms and examine the effects of entry by an additional private firm. Pal and White (1998) examine the effects of privatisation on strategic trade policy by incorporating strategic trade policy instruments in an international mixed model where a state-owned public firm competes with both domestic and foreign private firms. Fjell and Heywood (2002) consider a mixed oligopoly in which a public Stackelberg leader competes with both domestic and foreign private firms. Matsumura (2003) examines a Stackelberg mixed duopoly where a public firm competes with a

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[1] See, for instance, Ireland and Law (1982), Stephan (1982), or Bonin and Putterman (1987) for excellent surveys.

[2] The pioneering work on a theoretical model of a public firm is conducted by Merrill and Schneider (1966). See also Bös (1986, 2001), Vickers and Yarrow (1988), Cremer, Marchand, and Thisse (1989), or Nett (1993) for excellent surveys.

foreign private firm.

We examine the behaviors of one state-owned welfare-maximizing domestic firm and one labor-managed income-per-worker-maximizing foreign firm in a two-stage mixed model with lifetime employment as a strategic commitment. We consider the following situation. In the first stage, the state-owned firm and the labor-managed firm each independently decide whether or not to adopt lifetime employment. We consider a lifetime employment contract as a strategic commitment.[3] If a firm adopts lifetime employment, then it chooses an output level and enters into a lifetime employment contract with the number of employees necessary to achieve the output level. Hence, the firm's wage cost changes from a variable cost to a fixed cost. In the second stage, each firm independently chooses its actual output. We discuss the equilibrium of the quantity-setting mixed model.

The purpose of this paper is to show the equilibrium of the international mixed duopoly model of one state-owned welfare-maximizing domestic firm competes and one labor-managed income-per-worker-maximizing foreign firm with a lifetime employment contract as a strategic commitment.

The paper is organized as follows. In Section 2, we formulate the model. Section 3 gives supplementary explanations of the model. Section 4 discusses the equilibrium of the model. Section 5 concludes the paper. Finally, the Appendix provides formal proofs.

2. The model

Let us consider a mixed duopoly model with one state-owned welfare-maximizing domestic public firm (firm S) and one labor-managed income-per-worker-maximizing foreign private firm (firm L), producing perfectly substitutable goods. For the remainder of this paper, subscripts S and L denote firm S and firm L, respectively. The market price is determined by the inverse demand function $p(Q)$, where $Q = q_{\mathrm{S}} + q_{\mathrm{L}}$. We assume that $p' < 0$ and $p'' < 0$.

The market will be modeled by means of the following two-stage game. In the first stage, each firm independently decides whether or not to adopt lifetime employment. If firm $i (i = \mathrm{S,L})$ adopts lifetime employment, then it chooses output $q_i^* \geq 0$ and enters into a lifetime employment contract with the number of employees necessary to achieve q_i^*. In the second stage, each firm independently chooses its actual output q_i.

[3] For details see Ohnishi (2001, 2002).

Domestic social welfare, which is the sum of consumers' surplus and firm S's profit, is given by

$$W = \begin{cases} \int_0^Q p(x)dx - m_S q_S - f_S - pq_L & \text{if } q_L \geq q_L^*, \\ \int_0^Q p(x)dx - (m_S - w_S)q_S - w_S q_S^* - f_S - pq_L & \text{if } q_L \leq q_L^*, \end{cases} \tag{1}$$

where $m > 0$ is the total cost for each unit of output, $w \in (0, m]$ the wage cost for each unit of output, and $f > 0$ the fixed cost.

Furthermore, firm L's income per worker is given by

$$V_L = \begin{cases} \dfrac{p(Q)q_L - m_L q_L - f_L}{l_L(q_L)} & \text{if } q_L \geq q_L^*, \\ \dfrac{p(Q)q_L - (m_L - w_L)q_L - w_L q_L^* - f_L}{l_L(q_L)} & \text{if } q_L \leq q_L^*, \end{cases} \tag{2}$$

where $l_L(q_L)$ is the quantity of labor utilized. We assume that $l_L' > 0$ and $l_L'' > 0$.

We assume that firm S is less efficient than firm L in wage cost and other costs, i.e., $w_S > w_L$ and $m_S - w_S > m_L - w_L$.[4]

Firm S aims to maximize social welfare, and firm L aims to maximize its income per worker. In this paper, we will discuss the subgame perfect Nash equilibrium of the international mixed model.

3. Reaction functions

In this section, we derive both firms' reaction functions in quantities. Firm S's reaction function when the marginal cost is constantly equal to m_S is defined by

$$R_S(q_L) = \arg\max_{\{q_S \geq 0\}} \left[\int_0^Q p(x)dx - m_S q_S - pq_L \right], \tag{3}$$

and firm S's reaction function when the marginal cost is constantly equal to $m_S - w_S$ is defined by

$$R_S^{m-w}(q_L) = \arg\max_{\{q_S \geq 0\}} \left[\int_0^Q p(x)dx - (m_S - w_S)q_S - pq_L \right]. \tag{4}$$

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[4] This assumption is justified in Gunderson (1979), Cremer, Marchand, and Thisse (1989), and Nett (1993, 1994) and is often used in literature studying mixed markets. See, for instance, George and La Manna (1996), Mujumdar and Pal (1998), Pal (1998), Nishimori and Ogawa (2002), and Matsumura (2003). If firm S is more efficient than or equally as efficient as firm L, it is obvious that a monopoly by firm S is desirable. This assumption is made to eliminate such a trivial solution.

Therefore, if firm S selects q_S^* and adopts lifetime employment, then its best response is as follows:

$$R_S^L(q_L) = \begin{cases} R_S(q_L) & \text{if } q_S > q_S^*, \\ q_S^* & \text{if } q_S = q_S^*, \\ R_S^{m-w}(q_L) & \text{if } q_S < q_S^*. \end{cases} \tag{5}$$

The equilibrium occurs where each firm maximizes its objective with respect to its own output level, given the output level of its rival. Firm S aims to maximize social welfare with respect to its own output level, given the output level of firm L. The equilibrium must satisfy the following conditions: The first-order condition for firm S when the marginal cost for output is constantly equal to m_S is

$$p - m_S - p'q_L = 0, \tag{6}$$

the first-order condition for firm S when the marginal cost is constantly equal to $m_S - w_S$ is

$$p - m_S + w_S - p'q_L = 0, \tag{7}$$

and the second-order condition is

$$p' - p''q_L < 0. \tag{8}$$

Furthermore, we have

$$R_S'(q_L) = R_S^{m-w}{}'(q_L) = \frac{p''q_L}{p' - p''q_L}. \tag{9}$$

Hence, both $R_S(q_L)$ and $R_S^{m-w}(q_L)$ are upward sloping.

Firm L's reaction function when the marginal cost is constantly equal to m_L is defined by

$$R_L(q_S) = \arg\max_{\{q_L \geq 0\}} \left[\frac{p(Q)q_L - m_L q_L - f_L}{l_L(q_L)} \right], \tag{10}$$

and firm L's reaction function when the marginal cost is constantly equal to $m_L - w_L$ is defined by

$$R_L^{m-w}(q_S) = \arg\max_{\{q_L \geq 0\}} \left[\frac{p(Q)q_L - (m_L - w_L)q_L - w_L q_L^* - f_L}{l_L(q_L)} \right]. \tag{11}$$

Therefore, if firm L selects q_L^* and adopts lifetime employment, then its best response is as follows:

$$R_L^L(q_S) = \begin{cases} R_L(q_S) & \text{if } q_L > q_L^*, \\ q_L^* & \text{if } q_L = q_L^*, \\ R_L^{m-w}(q_S) & \text{if } q_L < q_L^*. \end{cases} \tag{12}$$

Firm L aims to maximize its income per worker with respect to its own output level, given the output level of firm S. The equilibrium must satisfy the following conditions: The first-order condition for firm L when the marginal cost for output is constantly equal to m_L is

$$(p'q_{\mathrm{L}} + p - m_{\mathrm{L}})l_{\mathrm{L}} - (pq_{\mathrm{L}} - m_{\mathrm{L}}q_{\mathrm{L}} - f_{\mathrm{L}})l_{\mathrm{L}}' = 0, \tag{13}$$

the first-order condition for firm L when the marginal cost is constantly equal to $m_{\mathrm{L}} - w_{\mathrm{L}}$ is

$$(p'q_{\mathrm{L}} + p - m_{\mathrm{L}} + w_{\mathrm{L}})l_{\mathrm{L}} - (pq_{\mathrm{L}} - m_{\mathrm{L}}q_{\mathrm{L}} + w_{\mathrm{L}}q_{\mathrm{L}} - w_{\mathrm{L}}q_{\mathrm{L}}^{*} - f_{\mathrm{L}})l_{\mathrm{L}}' = 0, \tag{14}$$

the second-order condition for firm L when the marginal cost for output is constantly equal to m_{L} is

$$(p''q_{\mathrm{L}} + 2p')l_{\mathrm{L}} - (pq_{\mathrm{L}} - m_{\mathrm{L}}q_{\mathrm{L}} - f_{\mathrm{L}})l_{\mathrm{L}}'' < 0, \tag{15}$$

and the second-order condition for firm L when the marginal cost is constantly equal to $m_{\mathrm{L}} - w_{\mathrm{L}}$ is

$$(p''q_{\mathrm{L}} + 2p')l_{\mathrm{L}} - (pq_{\mathrm{L}} - m_{\mathrm{L}}q_{\mathrm{L}} + w_{\mathrm{L}}q_{\mathrm{L}} - w_{\mathrm{L}}q_{\mathrm{L}}^{*} - f_{\mathrm{L}})l_{\mathrm{L}}'' < 0. \tag{16}$$

Furthermore, we have

$$R_{\mathrm{L}}'(q_{\mathrm{S}}) = -\frac{p''q_{\mathrm{L}}l_{\mathrm{L}} + p'(l_{\mathrm{L}} - q_{\mathrm{L}}l_{\mathrm{L}}')}{(p''q_{\mathrm{L}} + 2p')l_{\mathrm{L}} - (pq_{\mathrm{L}} - m_{\mathrm{L}}q_{\mathrm{L}} - f_{\mathrm{L}})l_{\mathrm{L}}''} \tag{17}$$

and

$$R_{\mathrm{L}}^{m-w}{}'(q_{\mathrm{S}}) = -\frac{p''q_{\mathrm{L}}l_{\mathrm{L}} + p'(l_{\mathrm{L}} - q_{\mathrm{L}}l_{\mathrm{L}}')}{(p''q_{\mathrm{L}} + 2p')l_{\mathrm{L}} - (pq_{\mathrm{L}} - m_{\mathrm{L}}q_{\mathrm{L}} + w_{\mathrm{L}}q_{\mathrm{L}} - w_{\mathrm{L}}q_{\mathrm{L}}^{*} - f_{\mathrm{L}})l_{\mathrm{L}}''}. \tag{18}$$

Since $l_{\mathrm{L}}'' > 0$, $l_{\mathrm{L}} - q_{\mathrm{L}}l_{\mathrm{L}}' < 0$, so that $p''q_{\mathrm{L}}l_{\mathrm{L}} + p'(l_{\mathrm{L}} - q_{\mathrm{L}}l_{\mathrm{L}}')$ is positive; that is, both $R_{\mathrm{L}}(q_{\mathrm{S}})$ and $R_{\mathrm{L}}^{m-w}(q_{\mathrm{S}})$ are upward sloping.

Both firms' reaction curves are drawn in Figure 1. R_i is firm i's reaction curve when the marginal cost for output is constantly equal to m_i, and R_i^{m-w} firm i's reaction curve when the marginal cost for output is constantly equal to $m_i - w_i$. Both firms' reaction curves are upward sloping. This means that both firms treat quantities as strategic complements. If firm S chooses $\bar{q}_{\mathrm{S}}^{*}$ and adopts lifetime employment, then from (5), firm S's reaction curve becomes the kinked bold broken lines. Furthermore, if firm L chooses $\bar{q}_{\mathrm{L}}^{*}$ and adopts lifetime employment, then from (12), firm L's reaction curve becomes the kinked bold lines.

4. Results

First, consider the case in which only firm S can adopt lifetime employment. Firm S aims to maximize social welfare. Therefore, it is thought that firm S will adopt lifetime employment if social welfare increases by doing so, while firm S will not adopt lifetime employment if social welfare decreases by doing so.

If firm S adopts lifetime employment, its marginal cost decreases and thus it increases its output. If firm S chooses $\bar{q}_{\mathrm{S}}^{*}$ and offers lifetime employment, then its reaction curve shifts for $q_{\mathrm{S}} \le \bar{q}_{\mathrm{S}}^{*}$.

In Figure 1, W^a, W^b and W^c are isowelfare curves when the marginal cost for output is constantly equal to m_S, and $W^a < W^b < W^c$. In R_S, increasing firm S's output increases firm L's output and social welfare. Firm S's unilateral lifetime employment solution can occur at the appropriate point of the segment AE. In R_L, social welfare is the highest at firm S's Stackelberg leader point. If firm S's Stackelberg leader point C is on AE, then firm S chooses $\overline{q}_S^*$ corresponding to C, and its reaction curve becomes the kinked bold broken lines drawn in Figure 1. The equilibrium is decided in a Cournot fashion, i.e. the intersection of firm S's and firm L's reaction curves gives us a unique equilibrium. Firm S's unilateral lifetime employment equilibrium occurs at C.

However, if firm S's Stackelberg leader point is to the right of E on R_L, then the equilibrium cannot occur at that point. In R_L, social welfare is the highest at firm S's Stackelberg leader point, and further the point on R_L deviates from its Stackelberg leader point, the more social welfare decreases. Hence, on AE, social welfare is highest at E, and the equilibrium occurs at E.

On the other hand, if neither firm adopts lifetime employment, then firm i's reaction curve is R_i, and thus the equilibrium occurs at A.

Now, we can state the following proposition:

Proposition 1. Suppose that firm S unilaterally adopts lifetime employment. Then in equilibrium social welfare is higher than in the Cournot game with no lifetime employment.

Second, consider the case in which only firm L can adopt lifetime employment. Firm L aims to maximize its income per worker. Therefore, it is thought that firm L will adopt lifetime employment if its income per worker increases by doing so, while firm L will not adopt lifetime employment if its income per worker decreases by doing so.

If firm L adopts lifetime employment, its marginal cost decreases and thus it increases its output. If firm L chooses $\overline{q}_L^*$ and offers lifetime employment, then its reaction curve shifts for $q_L \leq \overline{q}_L^*$. In Figure 1, V_L^α, V_L^β and V_L^γ are firm L's isoincome per worker curves when the marginal cost for output is constantly equal to m_L, and $V_L^\alpha < V_L^\beta < V_L^\gamma$. In R_L, increasing firm L's output increases firm S's output and decreases firm L's income per worker. Firm L's unilateral lifetime employment solution can occur at the appropriate point of the segment AF. If firm L chooses $\overline{q}_L^*$ corresponding to D and adopts lifetime employment, then its reaction curve becomes the kinked bold lines drawn in Figure 1. Hence, firm L's unilateral lifetime employment solution occurs at D.

Third, consider the case in which both firms can adopt lifetime employment. If social welfare

and firm L's income per worker when both firms adopt lifetime employment are each lower than when one firm unilaterally adopts lifetime employment, then there is no equilibrium where both firms will adopt lifetime employment. If not, however, then there is such an equilibrium.

If both firms adopt lifetime employment, then the intersection of their reaction curves becomes a point like B as drawn in Figure 1. The reaction curve of each firm will then has a flat segment at $\overline{q}_i^*$. Here, as $\overline{q}_{\mathrm{L}}^*$ becomes smaller, B moves downwards and firm L's income per worker becomes larger. Firm L's income per worker is higher at C than B. Firm L wants to deviate from B. Hence, B is not an equilibrium. Let C be a point where firm S unilaterally offers lifetime employment. Our equilibrium concept is subgame perfection and all information in the model is common knowledge. Firm S does not want to reduce $\overline{q}_{\mathrm{S}}^*$. Hence, C will be a possible equilibrium to the quantity-setting model with firm S and firm L.

Now, we can state the following proposition:

Proposition 2. Suppose that firm L adopts lifetime employment, given firm S's strategy. Then firm L's income per worker becomes smaller than in the equilibrium where firm L does not adopt lifetime employment.

Proposition 1 states that the best firm S can do is to adopt lifetime employment if firm L does not adopt lifetime employment. Furthermore, Proposition 2 states that the best firm L can do is not to adopt lifetime employment whether or not firm S does so.

The main result of this study is described by the following proposition:

Proposition 3. In the quantity-setting mixed model, there exists an equilibrium in which firm S enters into a lifetime employment contract with its employees while firm L does not.

5. Conclusion

We have examined an international mixed model in which a state-owned welfare-maximizing domestic public firm competes with a labor-managed income-per-worker-maximizing foreign private firm and have shown that there exists an equilibrium in which the state-owned domestic firm enters into a lifetime employment contract with its employees while the labor-managed foreign firm does not. Our result indicates that a state-owned domestic firm aggressively acting against a labor-managed foreign firm leads to social welfare maximization.

Appendix

First of all, we will present the next two supplementary lemmas.

Lemma 1. If firm i adopts lifetime employment, then in equilibrium $q_i = q_i^*$.

Proof. First, we prove that if firm S adopts lifetime employment, then in equilibrium $q_S = q_S^*$. Consider the possibility that $q_S < q_S^*$ in equilibrium. From (1), when firm S adopts lifetime employment, social welfare is

$$W = \int_0^Q p(x)dx - (m_S - w_S)q_S - w_S q_S^* - f_S - pq_L$$

$$= \int_0^Q p(x)dx - m_S q_S - (q_S^* - q_S)w_S - f_S - pq_L .$$

Here, since $q_S < q_S^*$, firm S employs the extra employees necessary to produce $q_S^* - q_S$. That is, firm S can increase social welfare by reducing q_S^*, and the equilibrium point does not change in $q_S \le q_S^*$. Hence, $q_S < q_S^*$ does not result in an equilibrium.

Consider the possibility that $q_S > q_S^*$ in equilibrium. From (1), we see that firm S's marginal cost is m_S. It is impossible for firm S to change its output in equilibrium because such a strategy is not credible. That is, lifetime employment does not function as a strategic commitment.

Next, we prove that if firm L adopts lifetime employment, then in equilibrium $q_L = q_L^*$. Consider the possibility that $q_L < q_L^*$ in equilibrium. From (2), when firm L adopts lifetime employment, its income-per-worker is

$$V_L = \frac{pq_L - (m_L - w_L)q_L - w_L q_L^* - f_L}{l_L}$$

$$= \frac{pq_L - m_L q_L - (q_L^* - q_L)w_L - f_L}{l_L} .$$

Here, since $q_L < q_L^*$, firm L employs the extra employees necessary to produce $q_L^* - q_L$. That is, firm L can increase its income per worker by reducing q_L^*, and the equilibrium point does not change in $q_L \le q_L^*$. Hence, $q_L < q_L^*$ does not result in an equilibrium.

Consider the possibility that $q_L > q_L^*$ in equilibrium. From (2), we see that firm L's marginal cost is m_L. It is impossible for firm L to change its output in equilibrium because such a strategy is not credible. That is, lifetime employment does not function as a strategic commitment. Q.E.D.

Lemma 2. Firm i's optimal output is larger when it adopts lifetime employment than when it does not.

Proof. First, we prove that firm S's welfare-maximizing output is larger when it adopts lifetime employment than when it does not. From (1), we see that lifetime employment will never increase the marginal cost of firm S. The first-order condition for firm S when its marginal cost is m_S is (6), and the first-order condition for firm S when its marginal cost is $m_S - w_S$ is (7). Here, w_S is positive. To satisfy (7), $p - m_S - p'q_L$ must be negative. Thus, firm S's welfare-maximizing output is larger when its marginal cost is $m_S - w_S$ than when its marginal cost is m_S.

Next, we prove that firm L's income-per-worker-maximizing output is larger when it adopts lifetime employment than when it does not. From (2), we see that lifetime employment will never increase the marginal cost of firm L. The first-order condition for firm L when its marginal cost is m_L is (13), and the first-order condition for firm L when its marginal cost is $m_L - w_L$ is (14). Here, w_L is positive. Furthermore, Lemma 1 shows that if firm L adopts lifetime employment and maximizes its income per worker, then $q_L = q_L^*$. To satisfy (14), $(p'q_L + p - m_L)l_L - (pq_L - m_L q_L - f_L)l_L'$ must be negative. Thus, firm L's income-per-worker-maximizing output is larger when its marginal cost is $m_L - w_L$ than when its marginal cost is m_L. Q.E.D.

Now, we will prove Propositions 1-3.

Proof of Proposition 1

Firm S's objective is to maximize social welfare. The first-order condition for firm S when the marginal cost for output is constantly equal to m_S is (6). Lemma 2 shows that firm S's welfare-maximizing output is larger when it adopts lifetime employment than when it does not. If firm S unilaterally adopts lifetime employment, then the equilibrium occurs at a point of R_L. We consider firm S's Stackelberg leader output when each firm's marginal cost is constantly equal to m_i. Firm S selects q_S, and firm L selects q_L after observing q_S. If firm S is the Stackelberg leader, then it maximizes social welfare $W(q_S, R_L(q_S))$ with respect to q_S. Therefore, firm S's Stackelberg leader output satisfies the first order condition:

$$p - m_S - p'q_L - p'q_L R_L' = 0. \tag{19}$$

From $p' < 0$ and $R_L' > 0$, to satisfy (19), $p - m_S - p'q_L$ must be negative. Hence, firm S's Stackelberg leader output exceeds its Cournot output. Furthermore,

$W = \int_0^Q p(x)dx - m_S q_S - f_S - pq_L$ is continuous and concave on q_S. In R_L, social welfare is the highest at firm S's Stackelberg leader point, and the further the point on R_L gets from firm S's Stackelberg leader point, the more social welfare decreases. Lemma 1 shows that $q_S = q_S^*$ in equilibrium. Thus, the proposition follows. Q.E.D.

Proof of Proposition 2

Firm L's objective is to maximize its income per worker. The first-order condition for firm L when the marginal cost for output is constantly equal to m_L is (13). Lemma 2 shows that firm L's income-per-worker-maximizing output is larger when it adopts lifetime employment than when it does not. If firm L unilaterally adopts lifetime employment, then the equilibrium occurs at a point of R_S. We consider firm L's Stackelberg leader output when each firm's marginal cost is constantly equal to m_i. Firm L selects q_L, and firm S selects q_S after observing q_L. If firm L is the Stackelberg leader, then it maximizes its income per worker $V_L(q_L, R_S(q_L))$ with respect to q_S. Therefore, firm L's Stackelberg leader output satisfies the first order condition:

$$(p'q_L + p - m_L)l_L - (pq_L - m_L q_L - f_L)l_L' + p'q_L R_S' = 0. \tag{20}$$

From $p' < 0$ and $R_S' > 0$, to satisfy (20), $(p'q_L + p - m_L)l_L - (pq_L - m_L q_L - f_L)l_L'$ must be positive. Hence, firm L's Stackelberg leader output is smaller than its Cournot output. Furthermore, $V_L = (p(Q)q_L - m_L q_L - f_L)/l_L(q_L)$ is continuous and concave on q_L. In R_S, firm L's income per worker is the highest at its Stackelberg leader point, and the further the point on R_S gets from firm L's Stackelberg leader point, the more firm L's income per worker decreases. Hence, if firm L unilaterally adopts lifetime employment, then firm L's income per worker becomes smaller than in the Cournot game equilibrium with no lifetime employment.

Suppose that each firm chooses q_i^* and enters into a lifetime employment contract with the number of employees necessary to achieve q_i^*. From Lemma 1, we see that $q_i = q_i^*$ if the bilateral lifetime employment point is an equilibrium. From (5) and (12), we see that each firm's reaction functions have a flat segment at q_i^*. $V_L = (p(Q)q_L - m_L q_L - f_L)/l_L(q_L)$ is continuous and concave on q_L. Hence, firm L can increase its income per worker by reducing q_L and q_L^*. Firm L maximizes its income per worker by reducing q_L and q_L^* to a point of R_L, given q_S and q_S^*. Our equilibrium concept is subgame perfection and all information in the model is common knowledge. Therefore, firm S does not reduce q_S and q_S^*. From (12), we see that firm L's lifetime employment does not function as a strategic commitment in R_L. Thus, the proposition follows. Q.E.D.

Proof of Proposition 3

In the first stage, each firm decides whether or not to adopt lifetime employment, and if firm i adopts lifetime employment, then it selects q_i^*. In the second stage, each firm chooses its actual output q_i independently, and social welfare and firm L's income per worker are decided. Hence, we can consider the following matrix:

		Firm L	
		Lifetime employment	No lifetime employment
Firm S	Lifetime employment	W^B, V_L^B	W^C, V_L^C
	No lifetime employment	W^D, V_L^D	W^A, V_L^A

From the preceding results, we see that $W^C > W^A$, $V_L^A > V_L^D$ and $V_L^C > V_L^B$. Thus, the equilibrium occurs at "lifetime employment" for firm S and "no lifetime employment" for firm L. Q.E.D.

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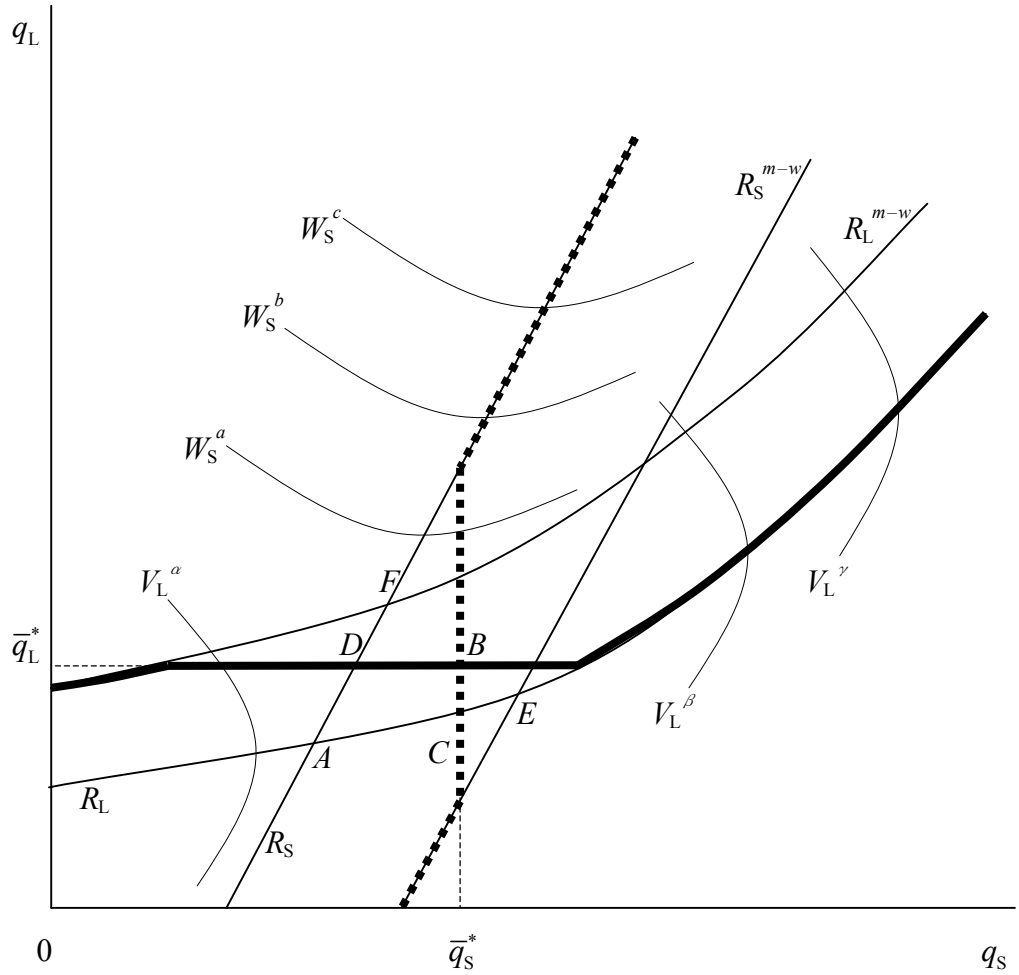

Figure 1. Reaction Curves in the Quantity Space