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

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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), Delbobo 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 years.\(^2\) 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.


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\(^1\) See, for instance, Ireland and Law (1982), Stephan (1982), or Bonin and Putterman (1987) 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. 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 \( Q = q_S + q_L \). We assume that \( p^f < 0 \) and \( p^n < 0 \).

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 \( i (i = S, L) \) 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 \( q_i \).

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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

\[ W = \begin{cases} 
\int_0^Q p(x)dx - m_s q_s - f_s - pq_L & \text{if } q_L \geq q_L^*, \\
\int_0^Q p(x)dx - (m_s - w_s)q_s - w_s q_s^* - f_s - pq_L & \text{if } q_L \leq q_L^*,
\end{cases} \]  

(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

\[ V_L = \begin{cases} 
p(Q)q_L - m_l q_L - f_L & \text{if } q_L \geq q_L^*, \\
l_l(q_L) & \text{if } q_L < q_L^*,
\end{cases} \]  

(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

\[ R_s(q_L) = \arg \max_{(q_s, q_L)} \left[ \int_0^Q p(x)dx - m_s q_s - pq_L \right], \]  

(3)

and firm S’s reaction function when the marginal cost is constantly equal to \( m_s - w_s \) is defined by

\[ R_{s}^{m-w}(q_L) = \arg \max_{(q_s, q_L)} \left[ \int_0^Q p(x)dx - (m_s - w_s)q_s - pq_L \right]. \]  

(4)

\(^4\) This assumption is justified in Gunderson (1979), Cremer, Marchand, and Thissse (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:

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

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

$$p - m_s - p'q_L = 0, \quad (6)$$

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

$$p - m_s + w_s - p'q_L = 0, \quad (7)$$

and the second-order condition is

$$p' - p''q_L < 0. \quad (8)$$

Furthermore, we have

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

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

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

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

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

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

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

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
\[ (p'q_L + p - m_L)l_L' - (pq_L - m_Lq_L - f_L)l_L' = 0, \]  
the first-order condition for firm L when the marginal cost is constantly equal to \( m_L - w_L \) is

\[ (p'q_L + p - m_L + w_L)l_L' - (pq_L - m_Lq_L + w_Lq_L - w_Lq_L^* - f_L)l_L' = 0, \]

the second-order condition for firm L when the marginal cost for output is constantly equal to \( m_L \) is

\[ (p''q_L + 2p')l_L' - (pq_L - m_Lq_L - f_L)l_L'' < 0, \]

and the second-order condition for firm L when the marginal cost is constantly equal to \( m_L - w_L \) is

\[ (p''q_L + 2p')l_L' - (pq_L - m_Lq_L + w_Lq_L - w_Lq_L^* - f_L)l_L'' < 0. \]

Furthermore, we have

\[ R_L(q_S) = -\frac{p''q_Ll_L' + p'(l_L - q_Ll_L')}{(p''q_L + 2p')l_L' - (pq_L - m_Lq_L - f_L)l_L''} \]  
and

\[ R_L^{m-w}(q_S) = -\frac{p''q_Ll_L' + p'(l_L - q_Ll_L')}{(p''q_L + 2p')l_L' - (pq_L - m_Lq_L + w_Lq_L - w_Lq_L^* - f_L)l_L''}. \]

Since \( l_L'' > 0, \ l_L - q_Ll_L' < 0 \), so that \( p''q_Ll_L' + p'(l_L - q_Ll_L') \) is positive; that is, both \( R_L(q_S) \) and \( R_L^{m-w}(q_S) \) 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 \( \bar{q}_S^* \) and adopts lifetime employment, then from (5), firm S’s reaction curve becomes the kinked bold broken lines. Furthermore, if firm L chooses \( \bar{q}_L^* \) 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 \( \bar{q}_S^* \) and offers lifetime employment, then its reaction curve shifts for \( q_S \leq \bar{q}_S^* \).
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 $q_S^*$ 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 $q_L^*$ and offers lifetime employment, then its reaction curve shifts for $q_L \leq q_L^*$. In Figure 1, $V_L^\alpha$, $V_L^\beta$ and $V_L^\gamma$ 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 $q_L^*$ 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 $\bar{q}_L^*$. Here, as $\bar{q}_L^*$ 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 $\bar{q}_S^*$. 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

$$W = \int_0^\alpha p(x)dx - (m_s - w_s)q_s - w_s q_s^* - f_s - pq_L$$

$$= \int_0^\alpha p(x)dx - m_s q_s - (q_s^* - q_s)w_s - f_s - pq_L.$$

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 $q_s \leq q_s^*$. 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 $q_L \leq q_L^*$. 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), $(p'q_L + p - m_L)q'_L - (pq_L - m_Lq_L - f_L)q'_L$ 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:

$$p - m_S - p'q_L - p'q_L R_L' = 0.$$  \hspace{0.5cm} (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,
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 \( q_L \). Therefore, firm L’s Stackelberg leader output satisfies the first order condition:

\[
(p'q_L + p - m_L)l_L - (pq_L - m_Lq_L - f_L)l'_L + p'q_LR_s' = 0.
\]

From \( p' < 0 \) and \( R_s' > 0 \), to satisfy (20), \( (p'q_L + p - m_L)l_L - (pq_L - m_Lq_L - f_L)l'_L \) must be positive. Hence, firm L’s Stackelberg leader output is smaller than its Cournot output. Furthermore, \( V_L = (pQl_L - mLq_L - f_L)l'_L(q_L) \) 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 \( q_i^* \). \( V_L = (pQl_L - mLq_L - f_L)/l'_L(q_L) \) 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 \( q_L^* \). 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:

<table>
<thead>
<tr>
<th>Firm L</th>
<th>Lifetime employment</th>
<th>No lifetime employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm S</td>
<td>$W^B, V^B_L$</td>
<td>$W^C, V^C_L$</td>
</tr>
<tr>
<td>No lifetime employment</td>
<td>$W^D, V^D_L$</td>
<td>$W^A, V^A_L$</td>
</tr>
</tbody>
</table>

From the preceding results, we see that $W^C > W^A$, $V^A_L > V^D_L$ and $V^C_L > V^B_L$. 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