

A Note on Capital Commitment and Cournot Competition with Labour-Managed and Profit-Maximising Firms

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I. Introduction

In a recent issue of *Australian Economic Papers*, Luca Lambertini and Gianpaolo Rossini (henceforth LR) attempt to analyse the strategic investment behaviour of a labour-managed firm (LMF) in an LM duopoly and that of an LMF and a profit-maximising firm (PMF) in a mixed duopoly. Concretely speaking, employing two-stage game models in which the firms make irrevocable commitments to investment in the first stage and choose outputs in the second stage, LR consider whether they overinvest or underinvest in capital. By contrast, in a conventional context Brander and Spencer (1983), Fudenberg and Tirole (1984), Bulow et al. (1985), and Lee (1985) have obtained the conclusion that PMFs overinvest (underinvest) in research and development (R & D) or advertising in Cournot (Bertrand) competition when employing it as a strategic way. Furthermore, Leahy and Neary (1997) and Haruna (1998) have described that whether or not the PMFs use a larger or smaller amount of R & D investment than that required to minimise its costs depends crucially on the rates of R & D spillovers.

LR assert that results derived in the Cournot LM and mixed

duopolies are in sharp contrast with the conventional results of, e. g., Brander and Spencer (1983). Their analytical intention attracts our interest, but we have two doubts about it. First, when LR make a comparative study with the conventional results, why do they employ a method different from the conventional method like Brander and Spencer (1983), and Bulow et al. (1985)? Especially, the method used in Section II of LR is problematic because the condition for cost minimisation for the LMF does not correctly correspond to that for maximisation of its per-capita profits: that is, there is no duality between both conditions. To make matters worse, when their analysis is reexamined along the conventional method, a serious problem also arises that makes their outcome of Proposition 1 meaningless: although an interior equilibrium in the simultaneous game based on their model is indispensable in order to examine the level of strategic investment, there is not such an equilibrium. Their model cannot thus provide a suitable criterion to judge whether the LMF underinvests or overinvests, unlike Brander and Spencer (1983), so that the discussion of LR does not hold. Secondly, even if there is an interior equilibrium in that simultaneous game, we have some doubt whether their results such as Propositions 1 and 2 can be generalised: namely, even if we take for granted that the analysis of LMFs always involves difficulties, we feel misgivings about their model, because it is too simple.

As the first purpose of this paper, we indicate an error included in the LR model, as mentioned above. In addition, it is shown that another serious problem newly arises even though their analysis is corrected. The second purpose is to reconsider the relationship between the levels of R & D and strategic commitment in both an LM and a mixed duopolies with R

& D spillovers and to compare with the conclusion derived in the conventional context, e. g., in Fudenberg and Tirole (1984), Bulow et al. (1985), Leahy and Neary (1997), and Haruna (1998) as well as Brander and Spencer (1983). Among others, Leahy and Neary (1997) and Haruna (1998) extend the previous discussion to more general one and demonstrate that the levels of R & D in fact rely on the levels of R & D spillovers.

The paper is organised as follows. In Section II we show that there is no consistency, i. e., duality, in the LR model and prove that their simultaneous game based on their model has no interior equilibrium. In Section III we consider the strategic R & D levels of LMFs in an LM duopoly with spillovers. It will be shown that, like PMFs in the conventional models, the LMFs have incentives to strategically overinvest or underinvest according as their outputs are strategic substitutes or complements. Section IV investigates the strategic investment behaviour of an LMF and a PMF in a mixed duopoly. When another type of firm is included in a duopoly, the behaviour of the LMF is influenced by it. Section V concludes.

II. A Lack of Duality in the Lambertini and Rossini Model and No Interior Equilibrium

LR point out that LMFs in an LM duopoly and an LMF and a PMF in a mixed duopoly will either overinvest or underinvest in physical capital when it is strategically used. Following their notation, $\partial C_i / \partial k_i = r - q_i^2 / k_i^2 = 0$ is derived as the condition for cost minimisation. They conclude that the LMF overinvests (underinvests) in capacity k_i when the

derivative of C_i is positive (negative), as expressed in Propositions 1 and 2. However, their conclusions are misleading because the maximisation problem of per-capita profits V_i as to the LMF does not correctly correspond to its minimisation one of C_i : that is, even if cost minimisation is achieved at the level of k_i' , V_i is not always maximised at k_i' .¹ Put it in another way, there is no duality between both conditions for minimisation and maximisation, while in conventional PMF models the duality rightfully holds. To settle this problem the conventional method should be adopted, as used in Brander and Spencer (1983), Bulow et al. (1985), Dixit (1986), Lee (1986), and Leahy and Neary (1997), and, otherwise, the results obtained under the LM and mixed duopolies may not be compared with the conventionally established results.

When we adopt that method, in the simultaneous game based on the LR model the first-order conditions for maximisation of per-capita profits are given by

$$\frac{\partial V_i}{\partial q_i} = \frac{k_i}{q_i^2} \left[a - 2q_i - q_j - \frac{2(pq_i - r_i k_i)}{q_i} \right] = 0 \quad (1)$$

$$\frac{\partial V_i}{\partial k_i} = \frac{pq_i - 2rk_i}{q_i^2} = 0, \quad (2)$$

where $p = a - q_i - q_j$ denotes the inverse demand function. Substituting

1 To verify this, as an example, let us see the conditions for maximisation and minimisation with respect to k_i . They are given, respectively, as

$$\frac{\partial V_i}{\partial k_i} = \frac{pq_i - 2rk_i}{q_i^2} = 0 \quad \text{and} \quad \frac{\partial C_i}{\partial k_i} = r - \frac{q_i^2}{k_i^2} = 0.$$

Both conditions are not the same in that different levels of investment are obtained from those.

conditions (1) into (2) yields $\partial V_i / \partial q_i = -k_i q_i = 0$. This demonstrates that each LMF produces no output. That is, there is no interior equilibrium in the simultaneous game of the LM duopoly, and the PM duopoly results in the monopoly of the PMF. The optimal (efficient) level of investment, i. e., a benchmark for comparison, should be given by that of investment under the simultaneous equilibrium. In the LR case, since a prerequisite for their discussion is lost, it is impossible to specify the relationship between capital commitment and its level. Hence Propositions 1 and 2 of LR are invalid in that they cannot make a correct comparison between their and the conventional conclusions.

III. The Effect of Strategic Commitment on the Cournot Duopoly of Labour-Managed Firms with R & D Spillovers

In this and the next sections we consider whether the conventional conclusion as to the strategic use of R & D is extended to both an LM and a mixed duopolies.

We first take up a two-stage model of Cournot LM duopoly, in which two firms determine the levels of R & D in the first stage and outputs in the second stage. After R & D decision the firms are engaged in quantity competition. On the other hand, R & D investment is made to reduce production costs before output decision, so it is used for a strategic objective.² It is assumed that there are R & D spillovers among the firms,

² In general, in most conventional models a strategic variable is R & D investment, but in Fudenberg and Tirole (1984) advertising is that variable. Papers that treat physical capital as such a variable like LR are few.

i. e., each firm cannot appropriate its technology and know-how acquired by R & D activities, so some or all of them flow out to the rival.³ In Brander and Spencer (1983), Fudenberg and Tirole (1984), and Bulow et al. (1985), such spillovers are, however, not incorporated: namely, they implicitly assume no spillovers.

The firms are LMFs, 1 and 2, producing a homogeneous good. The inverse demand function of a market takes form of $p = p(Q)$, $p'(Q) < 0$, where $Q = q_1 + q_2$ denotes industry output. We assume that each of the firms has a constant-returns-to-scale production function, $q_i = F^i(L_i, k_i)$. Production costs are composed of variable costs and fixed costs. Since $F^i(L_i, k_i)$ is linear homogeneous in L_i and k_i , the cost function of firm i is as follows⁴:

$$c_i(q_i) = c_i q_i + f_i,$$

where c_i is constant, and f_i is fixed costs. Labour input is also a linear function of output, i. e., $L_i = \delta_i q_i$, where $\delta_i > 0$. The demand and production functions are more general than those of LR. When making an investment in R & D to reduce their production costs, especially, marginal cost c_i , the firm must spend $e_i(x_i)$ in order to lower marginal cost by x_i , where $e_i(x_i)$ stands for the expenditure (cost) function of R & D and is convex in x_i , $de_i(x_i)/dx_i = e_i'(x_i) > 0$, $e_i''(x_i) > 0$, and $e_i(0) = 0$. As mentioned above, there are spillovers in terms of R & D investment, and β_i ,

3 d'Aspremont and Jacquemin (1988) first incorporate spillovers into a theoretical model and analyse the effects of them on output and R & D investment.

4 For the detail derivation of the cost function, see Haruna (1996).

$0 \leq \beta_i \leq 1$, refers to the spillover rate of firm i 's R & D.⁵ In the presence of the spillover effects firm i 's marginal cost is lowered by $x_i + \beta_i x_j$, $i \neq j$, as a result of the two firms' R & D. Thus it follows that the cost function is finally reduced to

$$(c_i - x_i - \beta_i x_j)q_i + f_i.$$

For simplicity we assume in the following discussion that the LMFs are symmetric: that is, $c_1 = c_2 = c$, $f_1 = f_2 = f$, and $e_1(x_1) = e_2(x_2)$.

Let us consider the nonstrategic, simultaneous game. The profits of LMF i are given by

$$\pi_i = [p(Q) - (c - x_i - \beta x_j)]q_i - e(x_i) - f.$$

The firm chooses output and the level of R & D so as to maximise per-capita profits (dividends):

$$\max_{q_i, x_i} V_i = \frac{\pi_i}{L_i} = \frac{[p(Q) - (c - x_i - \beta x_j)]q_i - e(x_i) - f}{\delta q_i}, \quad i = 1, 2.$$

Then the first-order conditions for maximisation are given by

$$\frac{\partial V_i}{\partial q_i} = \frac{[p(Q) - (c - x_i - \beta x_j) + p'(Q)q_i] - \delta V_i}{\delta q_i} = \frac{p'q_i^2 + e(x_i) + f}{\delta q_i^2} = 0 \quad (3)$$

$$\frac{\partial V_i}{\partial x_i} = \frac{q_i - e'(x_i)}{\delta q_i} = 0. \quad (4)$$

5 There are a lot of empirical researches concerning spillovers among firms and intra-industries. For example, see Cow and Helpman (1995).

A simultaneous Cournot–Nash equilibrium is characterised by (3) and (4).⁶ Let the costs of R & D be $g(x_i) = e(x_i) - x_i q_i$. The condition for minimisation of investment costs is $g'(x_i) = e'(x_i) - q_i = 0$, which is equivalent to (4). Since both conditions for maximisation and minimisation are dual, there is no inconsistency in the model unlike LR.

Let us turn to the firm's choice in the strategic two-stage game. The game should be solved backwardly. Then in the second stage the problem of the LMF is to choose output so as to maximise per-capita profits, given x_1 and x_2 :

$$\max_{q_i} V_i = \frac{[p(Q) - (c - x_i - \beta x_j)]q_i - e(x_i) - f}{\delta q_i}.$$

The first-order conditions for maximisation are

$$\frac{\partial V_i}{\partial q_i} = \frac{p' q_i^2 + e(x_i) + f}{\delta q_i^2} = 0. \quad (5)$$

On the other hand, the second-order conditions are

$$\frac{\partial^2 V_i}{\partial q_i^2} = \frac{2p' + p'' q_i}{\delta q_i} < 0. \quad (6)$$

A strategic Cournot–Nash equilibrium is characterised by conditions (5). We assume throughout the paper that the equilibrium is interior and locally stable. For stability it is required that

6 It is assumed that the second-order conditions are satisfied and that the equilibrium is interior and stable.

$$D = \left(\frac{\partial^2 V_1}{\partial q_1^2} \right) \left(\frac{\partial^2 V_2}{\partial q_2^2} \right) - \left(\frac{\partial^2 V_1}{\partial q_2 \partial q_1} \right) \left(\frac{\partial^2 V_2}{\partial q_1 \partial q_2} \right) > 0.$$

Then the two-stage game has a subgame-perfect Nash equilibrium.

The output reaction function of firm i is given by (5):

$$R_i(q_j) = \frac{p'q_i^2 + e(x_i) + f}{\delta q_i^2}. \tag{7}$$

The slope of the reaction curve is obtained by totally differentiating (5):

$$\frac{\partial q_i}{\partial q_j} = - \frac{\partial^2 V_i / \partial q_j \partial q_i}{\partial^2 V_i / \partial q_i^2}, \tag{8}$$

where $\partial^2 V_i / \partial q_j \partial q_i = p''/\delta$. This means that if outputs are strategic substitutes (complements), i. e., $\partial^2 V_i / \partial q_j \partial q_i < (>) 0$, then the curves are downward (upward)-sloping. With linear demands, the LMF's best response is obtained, independent of the rival's output, while the PMF's one is not independent. This is because the strategic characteristics which the outputs of the LMF and PMF have depend on their ownership structure. On the other hand, an increase in firm i 's investment shifts its own reaction curve rightwards, but does not the rival's one. This result is the same as the conventional result (Brander and Spencer, 1983). We note that spillovers do not have any effect on the investment decision of the LMF; in other words, it receives no benefit from the rival's investment.

Examine the effects of a change in investment on the outputs. Differentiating (5) with respect to it and solving the equations yields

$$\frac{\partial q_i}{\partial x_i} = -\frac{(rx_i/\delta q_i^2)(\partial^2 V_j/\partial q_i^2)}{D} > 0$$

$$\frac{\partial q_j}{\partial x_i} = \frac{(rx_i/\delta q_i^2)(\partial^2 V_j/\partial q_i \partial q_j)}{D}.$$
(9)

These results show that an increase in x_i causes firm i 's output to increase and firm j 's output to decrease (increase) if their outputs are strategic substitutes (complements).

Next let us go back to the first stage. Here the LMF chooses the level of investment so as to maximise per-capita profits. We differentiate $V_i(x_i)$ with respect to x_i to obtain the first-order conditions:

$$\frac{\partial V_i}{\partial x_i} = \frac{\partial V_i}{\partial q_i} \frac{\partial q_i}{\partial x_i} + \frac{\partial V_i}{\partial q_j} \frac{\partial q_j}{\partial x_i} + \frac{\partial V_i}{\partial x_i} = \frac{p'(Q)}{\delta} \frac{\partial q_j}{\partial x_i} = 0, \quad i \neq j, \quad (10)$$

where $\partial V_i/\partial q_i = 0$ from (5), and $\partial V_i/\partial q_j = p'(Q)/\delta < 0$. A first-stage Cournot-Nash equilibrium is derived from (10). For simplicity, we assume that it is an interior and locally stable equilibrium. We, moreover, assume throughout this and the next sections that the second-order conditions for maximisation are satisfied although we do not, particularly, mention.

Consider the optimal level of R & D investment in the strategic game and compare with that in the simultaneous game. For comparison, we must know the sign of the second term on the right-hand side of (10). The term is the strategic term which generally appears in nonsimultaneous games (see Bulow et al., 1985; Dixit, 1986). It follows from (9) that the sign of the term is negative or positive according as firm i regards its output as a strategic substitute or complement for firm j 's output.

Consequently, when their outputs are strategic substitutes (complements), it follows that

$$\frac{dV_i}{dx_i} = \frac{p'(Q)}{\delta} \frac{\partial q_j}{\partial x_i} + \frac{\partial V_i}{\partial x_i} > (<) \frac{\partial V_i}{\partial x_i}.$$

Taking condition (4) into consideration, we find that as long as outputs are strategic substitutes (complements), the LMF chooses a higher (lower) level of R & D than the optimal level, where the costs of R & D are minimised. We establish the following proposition:

Proposition 1. In an LM duopoly, when making a strategic use of R & D, the LMFs have incentives to overinvest (underinvest) in R & D provided that their outputs are strategic substitutes (complements), irrespective of spillovers.

These results are fundamentally the same as the conventional results derived by Bulow et al. (1985), and Brander and Spencer (1983). If we look into the conclusion of the proposition in more detail, we find some difference between it and the conventional conclusion.⁷ It is of great interest that a difference in firm ownership structure seldom has an effect on its investment behaviour. Moreover, the LMF determines the amount of R & D, independent of its spillover rate, unlike the PMF's case (Leahy and Neary, 1997; Haruna, 1998).

⁷ It is worthy to note that the conditions for outputs to be strategic substitutes and complements for a PMF and an LMF are a little different. Owing to this, the conventional conclusion is not perfectly the same as that obtained here.

IV. The Effect of Strategic Commitment on the Cournot Mixed Duopoly of a Labour-Managed and a Profit-Maximising Firms with R & D Spillovers

By replacing one LMF by a PMF, we consider the level of R & D in a mixed duopoly. The structure of the model except for this replacement is kept unchanged. Let the LMF be firm 1 and the PMF be firm 2. The objective of the PMF is to maximise profits, which are

$$\pi_2 = [p(Q) - (c - x_2 - \beta x_1)]q_2 - e(x_2) - f.$$

We consider second-stage Cournot-Nash equilibrium in the two-stage game model. As for the LMF, the first-order and second-order conditions have already been derived as (5) and (6). On the other hand, the first-order and second-order conditions for the PMF are given by

$$\begin{aligned} \frac{\partial \pi_2}{\partial q_2} &= p(Q) - (c - x_2 - \beta x_1) + p'(Q)q_2 = 0 \\ \frac{\partial^2 \pi_2}{\partial q_2^2} &= 2p' + p''q_2 < 0. \end{aligned} \tag{11}$$

These are the conditions obtained in the conventional analysis. The equilibrium of the mixed duopoly is characterised by (5) and (11). It is assumed to be interior and locally stable. The requirement for stability is

$$D' = \left(\frac{\partial^2 V_1}{\partial q_1^2} \right) \left(\frac{\partial^2 \pi_2}{\partial q_2^2} \right) - \left(\frac{\partial^2 V_1}{\partial q_2 \partial q_1} \right) \left(\frac{\partial^2 \pi_2}{\partial q_1 \partial q_2} \right) > 0,$$

where $\partial^2 V_1 / \partial q_2 \partial q_1 = (p' + p''q_1) / \delta q_1$ and $\partial^2 \pi_2 / \partial q_1 \partial q_2 = p' + p''q_2$. The output reaction function of the LMF is $R_1(q_2)$, as shown by (7), and that of the

PMF is $R_2(q_1) = p(Q) - (c - x_2 - \beta x_1) + p'(Q)q_2$ from (11). The slope of the latter's reaction curve depends on the sign of $\partial^2 \pi_2 / \partial q_1 \partial q_2$, because $\partial^2 \pi_2 / \partial q_2^2 < 0$: namely, if the PMF regards its output as a strategic substitute (complement) for the LMF's output, then the curve slopes downwardly (upwardly). We find that, given $0 < p'' < -p'/q_2$, the reaction curve of the PMF slopes downwardly, but that of the LMF slopes upwardly. This is because there is a difference between an LMF and a PMF in terms of the strategic characteristics of outputs. An increase in x_2 causes the reaction curve of the PMF to shift rightwards and keeps the LMF's one constant, while an increase in x_1 causes the reaction curves of both firms to shift rightwards. The strategic effect of investment is a little different by the type of firm. This difference is caused by the existence of spillover β : namely, the LMF's investment is beneficial to the PMF, but the reverse is not the case.

Let us proceed to the decision stage of investment. In the first stage the first-order conditions for maximisation are

$$\frac{dV_1}{dx_1} = \frac{p'}{\delta} \frac{\partial q_2}{\partial x_1} + \frac{\partial V_1}{\partial x_1} = 0 \tag{12}$$

$$\frac{d\pi_2}{dx_2} = p'q_2 \frac{\partial q_1}{\partial x_2} + \frac{\partial \pi_2}{\partial x_2} = 0, \tag{13}$$

where $\partial V_1 / \partial q_1 = \partial \pi_2 / \partial q_2 = 0$ from the first-order conditions in the second stage. Conditions (12) and (13) give us a first-stage Cournot-Nash equilibrium. Then the two-stage game has a subgame-perfect Nash equilibrium. Both $(p'/\delta)(\partial q_2 / \partial x_1)$ and $(p'q_2)(\partial q_1 / \partial x_2)$ on the right-hand sides of (12) and (13) are the strategic term. Whether or not the firms overinvest relies on their signs. Differentiating (12) and (13) with respect

to x_1 and x_2 , respectively, yields

$$\frac{\partial q_2}{\partial x_1} = \frac{(e'(x_1)/\delta q_1^2)(\partial^2 \pi_2 / \partial q_1 \partial q_2) - \beta(\partial^2 V_1 / \partial q_1^2)}{D'} \quad (14)$$

$$\frac{\partial q_1}{\partial x_2} = \frac{\partial^2 V_1 / \partial q_2 \partial q_1}{D'}. \quad (15)$$

For example, $\partial q_1 / \partial x_2$ gets zero and positive (negative) for linear and convex (concave) demands, respectively. Hence the strategic term in (12) is negative if outputs are not strategic substitutes for the PMF, while it is of either sign if not so. With no spillovers, the term gets negative (positive) if they are strategic complements (substitutes). By contrast, the term in (13) is negative or positive according as outputs are strategic complements or substitutes for the LMF.

Before going ahead, we examine the level of investment in the simultaneous game. Then the first-order condition for the LMF is given by (4), and that for the PMF is given by

$$\frac{\partial \pi_2}{\partial x_2} = q_2 - e'(x_2) = 0. \quad (16)$$

When satisfying (4) and (16), the investments in R & D of the LMF and PMF are made at the level minimising its costs.

Comparing (12) and (4), and (13) and (16), we find that if $\partial q_j / \partial x_i$, $i \neq j$, is positive (negative), then firm i has an incentive to use investment to a larger (lower) level than that required to minimise its costs. When we make use of (14) and (15), this result is mentioned as follows. Provided that outputs are strategic complements for the LMF and PMF, they will underinvest in R & D, but on the other hand, provided that they are

strategic substitutes, the PMF will overinvest, but the LMF may or may not overinvest: with no spillovers, the latter will overinvest. The results are summarised as the following proposition:

Proposition 2. In a mixed duopoly with an LMF and a PMF,

(i) provided that outputs are strategic substitutes, the PMF will overinvest in R & D in the strategic game, and the LMF may or may not overinvest, but, with no spillovers, it will overinvest; and

(ii) provided that they are strategic complements, the PMF and LMF both will underinvest in R & D in the strategic game.

The result as to the PMF is the same as the conventional result (e. g., Brander and Spencer, 1983; Bulow et al., 1985), however the result as to the LMF is in sharp contrast with the latter result and Proposition 1. The reason for this lies in the existence of spillovers, that is, the investment behaviour of the LMF is affected by the introduction of the PMF into the model. We find that, given linear demands, the PMF makes an overinvestment in R & D, but the LMF makes an optimal investment. The results of Proposition 2 are unambiguously different from the results of Leahy and Neary (1997) and Haruna (1998) that whether PMFs overinvest or underinvest depends crucially on the rates of R & D spillovers. Moreover, comparing Propositions 1 and 2, we note that in the absence of spillovers it depends on firm ownership structure (or organisation) whether they play a role in firms' choices of investment.

V. Conclusion

It is commonly recognised in the conventional discussions that in strategic games PMFs will have incentives to use a more or less level of investment than its efficient level. Although LR have attempted to examine whether the conventional conclusion is extended to a pure LM and a mixed duopolies, a duality between the conditions for minimisation and maximisation with respect to capacity is lost in their model. Owing to this, their Proposition 1 is invalid. To avoid such a problem, they should rather use the same method as the conventional one to judge whether firms overinvest or underinvest: namely, the optimal level of investment should be derived from the condition for its cost minimisation in a nonstrategic, simultaneous game. Otherwise, it is difficult to elucidate whether firms strategically overinvest or underinvest. First of all, as a prerequisite for comparison, an interior equilibrium must exist in the simultaneous game. This must be the same with the LM and mixed duopolies. However, to make matters worse, when we attempt to analyse the investment behaviour of the duopolies along the conventional way, it is proved that there is not such an equilibrium in the simultaneous game based on the LR model, unlike the conventional game model. This leads to a misfortune result for their model that their Propositions lack validity. Anyway, their assertions are not established.

Secondly, we have provided alternative duopoly models with R & D more general than LR, and have demonstrated that the conclusion as to investment obtained under the LM duopoly is fundamentally the same as that under the conventional PM duopoly. What is of interest is that the R & D level of the LMF is chosen, independent of R & D spillovers. This

obviously contrasts with the conventional result. On the other hand, the result as to the PMF in the mixed duopoly is the same as the conventional result, but the result as to the LMF in it is different from that in the LM duopoly; particularly, the level of the former's investment is obviously affected by a spillover rate.

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This paper shows that the discussion of Lambertini and Rossini (1998) as to the strategic investment levels of labour-managed firms in a labour-managed (LM) duopoly is misleading. This is due to the fact that there is no duality between the conditions for maximisation and minimisation, and what is worse, an equilibrium needed for comparison is interior when the investment behaviour of the firms is discussed along the conventional method. We reconsider whether they overinvest or underinvest in R & D, employing a more general model with R & D spillovers. It is demonstrated that results obtained in the LM duopoly are similar to those in a conventional duopoly of profit-maximising firms.