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Abstract

This paper analyzes the effect of a devaluation of the domestic currency on the behaviour of a labour-managed firm which sells in both domestic and foreign markets and faces competition only in the foreign market. It is shown that with high enough revenues from the domestic market, the labour-managed firm will sell less at home and more abroad after the devaluation, thus reacting in the same way as a profit-maximizer. An analogous reaction occurs when the multimarket labour-managed firm receives a small export subsidy. The paper therefore extends and reverses the results of Mai and Hwang (1989) and Okuguchi (1991) who showed that under certain conditions a labour-managed firm will sell less abroad after the introduction of an export subsidy.

Keywords: Labour-managed Firm, Mixed Duopoly.

JEL Classification Numbers: L13, L21, F12.

1 Introduction

The objective function of state-owned firms in Eastern Europe is controversial. The standard approach is to assume that a state-owned firm maximizes social welfare. However, according to many economists, it is more appropriate to assume that state-owned firms in this region behave like labour-managed firms which maximize income per head[1].

It is well known in the literature that the upward shift of the demand function leads the labour-managed firm (henceforth LMF) to contract production and employment in order to get higher income per capita. This "perverse" effect however did not occur in Poland: after a large devaluation of the Polish currency at the beginning of 1990, one could observe a huge expansion of exports (roughly 40%[2]) by the state-owned sector to the hard currency area.

We show that such an effect is not at odds with the behaviour of the LMF. In particular, we demonstrate that for a LMF selling at home and abroad, a devaluation of the domestic currency can lead to an increase of the foreign sales (if sales in the domestic market are high enough). Thus, the LMF can act in the same way as a profit-maximizing firm (PMF henceforth). The subsequent analysis also confirms this result for a duopoly in the foreign market with a foreign PMF. In this way we extend and reverse the results obtained by Mai and Hwang (1989) and Okuguchi (1991). These authors have studied the effect of an export subsidy in a duopoly model of international trade with labour-managed and profit maximizing firms. They found that an increase in the export subsidy for a LMF decreases its export and increases the export of a PMF if both firms export their products to a third country, but do not

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[1]For instance, since 1990 we can observe a strong managerial role of the Workers Council body in Poland, which is elected by workers for a three years period and obtains full authority for firing and hiring managers and veto power over the strategic decisions of the firms [Frydman and Wellisz (1991)]. Schaffer (1991, 1992) argues that state-owned firms in Poland should be treated as labour-managed firms during the transition period.

[2]Schaffer (1992, p.59).

sell in the domestic market[3].

Contrary to Mai-Hwang and Okuguchi, we can say that an export subsidy can be an effective policy tool to adjust a labour-managed economy in order to expand in a foreign market. More generally, our model also shows that for a multimarket LMF the upward shift of the demand function in one market does not necessarily lead to a "perverse reaction", i.e., a reduction of sales in this market.

Related work by Horowitz (1991) also analyzed the international duopoly model with a PMF and a LMF in which firms sell part of their production in the domestic market and compete in a third market. In Horowitz's paper the production function is linear and he considers a specific kind of increase in demand. As a result, in his model sales increase in the market where demand has increased and go down in another market. Our model uses unspecified production function, and is thus more general. We also identify under which conditions the price discriminating LMF increases the sales in the market after an increase in demand.

The paper is organized as follows. In section 2 we show under which conditions the labour-managed monopolist increases exports after the devaluation and illustrate the results with a linear example. The results from section 2 are confirmed in section 3 in which we analyze a duopoly in the foreign market. In section 4, high returns to scale from labour and/or small sales in the foreign market are shown to imply an increase of exports for the LMF after the introduction of an export subsidy. Moreover, the introduction of an export subsidy can lead to a welfare increase in the domestic country.Section 5 concludes. The appendix contains some computations connected with the linear example and the welfare effects.

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[3]Note that the effect of the export subsidy is equivalent to a devaluation of the currency rate, since both cause an upward shift of the demand curve for the exporting firm. Therefore an analysis of the effects of a devaluation can be easily extended to the case of an export subsidy.

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2 A Labour-managed Monopoly

Consider a labour-managed firm which produces one product for the domestic market and exports it to the foreign market. As is widely assumed, instead of attempting to maximize profit, the LMF seeks to maximize net income per worker. We treat a LMF as a monopolist in both the domestic and foreign market and assume that the LMF is able to discriminate between the markets, implying that there is no arbitrage. The income per capita can be specified as follows:

$$Y = w + \frac{\Pi}{l}, \tag{1}$$

where w denotes the wages, l denotes labour, and Π denotes profits. Profits are given by

$$\Pi = R^1(q_1) + eR^2(q_2) - wl - K, \tag{2}$$

where q_1, q_2 are quantities sold in the domestic and foreign markets respectively; R^1, R^2 are concave revenue functions from the foreign and domestic market respectively; K is a fixed cost and e is the exchange rate defined in terms of the domestic currency.

Let

$$l = g(q_1 + q_2), \tag{3}$$

be a labour input function for the LMF; we assume that g is increasing and convex and that $g(0) = 0$.[4] Substituting (3) and (2) into (1) and rearranging the terms yields the usual maximand for the LMF

$$Y = \frac{R^1(q_1) + eR^2(q_2) - K}{g(q_1 + q_2)}. \tag{4}$$

The labour-managed monopolist, hereafter LMM for short, is supposed to maximize Y by choosing the quantities q_1 and q_2 sold in two markets.

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[4]If $q = f(l)$ is a production function for the LMF with $f(0) = 0$, $f' > 0$ and $f'' \leq 0$ then g is defined as an inverse function of f. Note that in this case we assume constant or diminishing returns to scale.

The first-order conditions are given by

$$Y_{q_1} = \frac{1}{g}(R^1_{q_1} - g'Y) = 0, \tag{5}$$

$$Y_{q_2} = \frac{1}{g}(eR^2_{q_2} - g'Y) = 0, \tag{6}$$

where the derivatives of Y and R^i are denoted by subscripts. (5) and (6) imply the general price discrimination rule: equalization of marginal revenues between markets. Moreover, for $R^1(q_1) = q_1 p_1(q_1)$, $R^2(q_2) = q_2 p_2(q_2)$ and $e = 1$ we get from (5) and (6)

$$p_1(q_1)\left[1 - \frac{1}{|\epsilon_1|}\right] = p_2(q_2)\left[1 - \frac{1}{|\epsilon_2|}\right] = g'Y, \tag{7}$$

where ϵ_i is the elasticity of demand for market i. Hence, similar to a profit-maximizing monopoly, the LMM will charge the lower price in the market with the more elastic demand.

The Hessian matrix of the problem is

$$H = \begin{bmatrix} Y_{q_1 q_1} & Y_{q_1 q_2} \\ Y_{q_2 q_1} & Y_{q_2 q_2} \end{bmatrix} = \begin{bmatrix} R^1_{q_1 q_1} - g''Y & -g''Y \\ -g''Y & eR^2_{q_2 q_2} - g''Y \end{bmatrix}. \tag{8}$$

Assuming that the second-order conditions are satisfied, i.e., that the Hessian H is negative definite, we can evaluate the effect of a devaluation of the domestic currency on sales by totally differentiating Eqs.(5)-(6) with respect to q_1, q_2 and e. This yields

$$H \begin{bmatrix} dq_1 \\ dq_2 \end{bmatrix} = \begin{bmatrix} g'R^2/g \\ (g'R^2/g) - R^2_{q_2} \end{bmatrix} de. \tag{9}$$

From (5), (6), (8), and (9), we get

$$\frac{dq_1}{de} = \frac{1}{\det H}[\overbrace{eR^2_{q_2 q_2}}^{(-)} \overbrace{(g'R^2/g)}^{(+)} - \overbrace{g''(Y)^2/e}^{(+)}] < 0, \tag{10}$$

with the first "$\frac{1}{\det H}$" marked $(+)$.

$$\frac{dq_2}{de} = \frac{1}{\det H}\{Y_{q_1 q_1}[(g'R^2/g) - R^2_{q_2}] + g'g''R^2Y/g\}. \tag{11}$$

with $\frac{1}{\det H}$ marked $(+)$, $Y_{q_1 q_1}$ marked $(-)$, and $g'g''R^2Y/g$ marked $(+)$.

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We see that the sales in the domestic market always go down after a devaluation, whereas the way in which foreign sales change depends on the sign of expression $(g'R^2/g) - R_{q_2}^2$. If this expression is negative, then foreign sales go up after a devaluation[5]. From the first-order condition (6) we obtain

$$-[(g'R^2/g) - R_{q_2}^2] = \frac{1}{eg}(R^1 - K).[6] \qquad (12)$$

From (12), if the revenue in the domestic market is greater than fixed costs, then the LMM increases sales in the foreign market. Note that in this case the LMM behaves as a profit-maximizing monopolist which increases production in the foreign market after a devaluation. If the expression $(g'R^2/g) - R_{q_2}^2$ is positive, but close to zero, we can also expect a reaction from the LMM analogous to that of a PMF. Generally, if the expression $(g'R^2/g) - R_{q_2}^2$ is positive then the reaction of the LMM in the foreign market is unclear, assuming that the optimal level of Y is positive.

Figure 1 illustrates these results. The curve AB represents the revenues from the domestic market R^1; the curve CD represents the difference $R^1 - K$. Let q_1^b and q_2^b be the optimal sales if the monopolist sells in both markets. If q_1^b lies between the points E and F[7], then $R^1 - K > 0$ and the LMM increases foreign sales after a devaluation. If q_1^b lies to the left of point F, the change in foreign sales is unclear.

For the monopolist who sells only in the foreign market, the expression (12) is always negative (because $R^1 = 0$) and a devaluation always leads to a decrease of foreign sales. This well known result shows that

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[5]We implicitly assume that optimal level of income per head Y is positive.

[6]Note that we can easily extend our analysis to the situation where the LMF is a price-taker in the foreign market. In this case the foreign revenues are $R^2(q_2) = p_2 q_2$ and

$$-[(g'R^2/g) - R_{q_2}^2] = p_2\left(1 - \frac{g'q_2}{g}\right).$$

Hence, if $g'q_2/g < 1$ then the LMF increases foreign sales after a devaluation. The condition $g'q_2/g < 1$ is discussed in Section 4.

[7]Point q_1^b must lie to the left of E. If q_1^b lies to the right of E then, by moving it towards E, we can increase revenues R^1 and decrease labour input g, thus increase income per head Y.
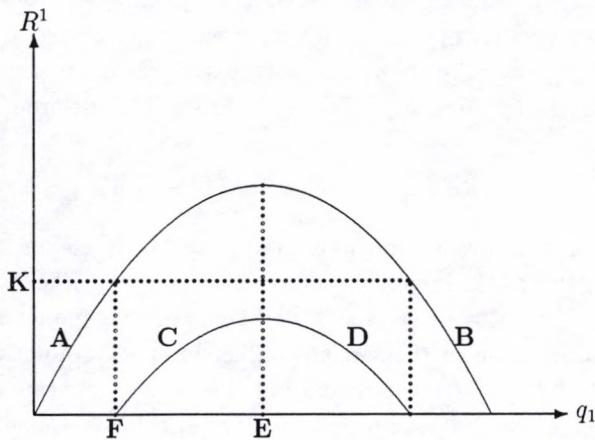
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Figure 1:

a LMF behaves in the opposite way to a PMF. However, as we have shown, the LMM which operates in two markets can react to the upward shift of the demand function in one market in the same way as a profit-maximizing monopoly.

The underlying intuition for the above results is as follows. If the LMM operates only in the foreign market then it solves the following problem

$$\max_q \left(\frac{eR^2(q)}{g(q)} - \frac{K}{g(q)} \right). \tag{13}$$

The first term in (13) denotes the revenue per worker (RW), the second is cost per worker (CW). The optimum is achieved when marginal revenue per worker (MRW) is equal to marginal cost per worker (MCW). Figure 2 illustrates this. The curve MRW' represents the marginal costs per worker before a devaluation. We can see that both functions MRW' and MCW are negative; the first because the revenue function $R^2(q)$ is concave and the labor-input function $g(q)$ is convex (see Appendix A), the second because additional production leads to an increase of employment
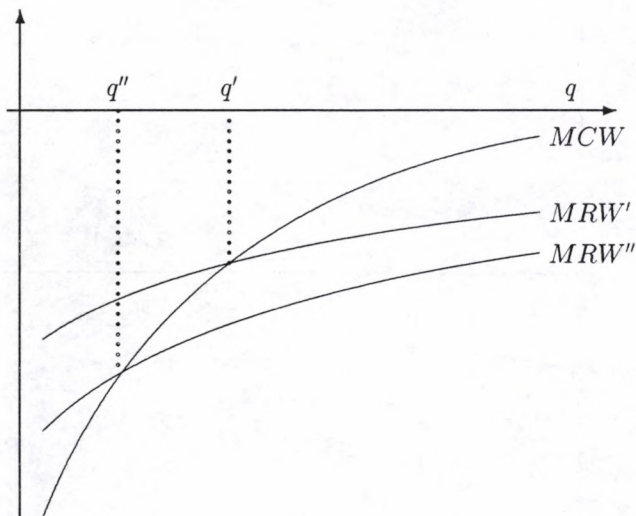
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Figure 2:

and reduces the fixed costs per worker. The optimal level of output is equal to q'. After a devaluation the marginal revenue per worker function shifts to MRW'' and output goes down to q''. In other words it is more favourable to reduce output in order to obtain a higher income per head.

Consider now the LMM which operates in two markets. Let q_1^*, q_2^* be the optimal sales in the domestic and foreign markets respectively. By definition we have q_2^* as a solution of the following problem

$$\max_{q_2} \frac{R^1(q_1^*) + eR^2(q_2) - K}{g(q_1^* + q_2)} = \max_{q_2} \left(\frac{eR^2(q_2)}{g(q_1^* + q_2)} - \frac{K - R^1(q_1^*)}{g(q_1^* + q_2)} \right). \quad (14)$$

The first term on the right-hand side of (14) represents revenue per worker in the foreign market. The second term on the right-hand side of (14) represents the "residual" costs per worker. They are residual because the revenues in the domestic market $R^1(q_1^*)$ are subtracted from the total fixed costs K. Note that for revenues from the domestic market $R^1(q_1^*)$
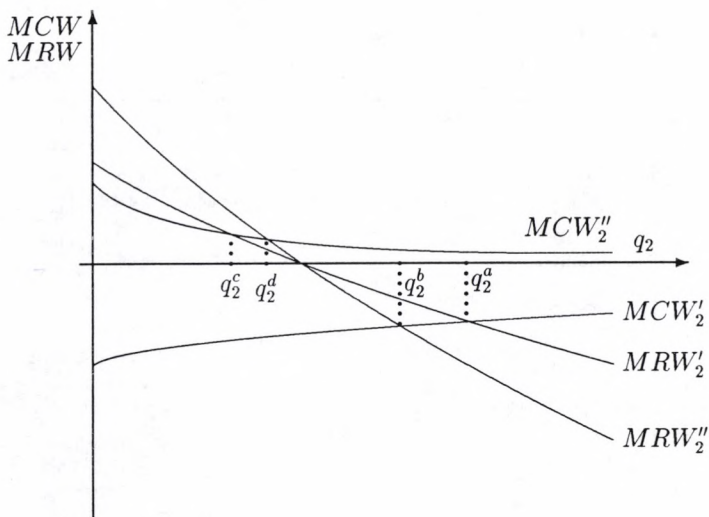
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Figure 3:

higher than fixed costs K, the residual costs per worker are negative. The optimum in (14) is achieved when marginal revenue per worker in the foreign market (MRW_2) is equal to marginal residual costs per worker (MCW_2).

Figure 3 illustrates. The curve MRW_2' represents marginal average revenues per worker before a devaluation. These revenues are positive for small values of sales in the foreign market q_2 since the revenue created by additional sales is divided among all workers (see Appendix A). The curve MCW_2' represents the case when $K - R^1(q_1^*) > 0$, in other words when the residual costs are positive. This situation is analogous to the one in which the LMM operates in only one market. After a devaluation the marginal revenue per worker shifts to MRW_2''. As a result, sales in the foreign market decrease from q_2^a to q_2^b.

As soon as the domestic revenues $R^1(q_1^*)$ cover the fixed costs K,

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the marginal residual costs per worker become positive; this situation is illustrated by curve MCW_2'' in figure 3. The initial optimal level of sales is now q_2^c, and after a devaluation it increases to q_2^d. Thus revenues from the domestic market can be treated as a subsidy to the residual fixed costs. Such a subsidy makes the marginal residue costs per worker positive. As a result the LMF reacts to any exogenous shock in the foreign market analogously to the PMF.

The change of total sales for the LMM can be obtained from (10) and (11) as

$$\frac{dQ}{de} = \frac{dq_1}{de} + \frac{dq_2}{de} = \underbrace{\frac{1}{\det H}}_{(+)} \{ \underbrace{R_{q_1 q_1}^1}_{(-)} [(g' R^2/g) - R_{q_2}^2] + \underbrace{e R_{q_2 q_2}^2}_{(-)} \underbrace{g' g'' R^2 Y/g}_{(+)} \}. \tag{15}$$

(15) shows that, if the expression $(g' R^2/g) - R_{q_2}^2$ is positive, then the total change in sales is negative. In particular, if the markets are identical, i.e., the revenue functions are the same, then, from (6), we get

$$\frac{dQ}{de} = \underbrace{\frac{R_{q_2 q_2}^2}{\det H}}_{(-)} [(2g' R^2/g) - R_{q_2}^2] = \underbrace{\frac{R_{q_2 q_2}^2}{\det H}}_{(-)} \underbrace{(g' K/g)}_{(+)} < 0. \tag{16}$$

Thus, if the markets are identical, the total change in sales is always negative, although we do not exclude the possibility that the sales in the foreign market will rise.

Example: A Linear Model

As an example let us consider the linear inverse demand functions $p_1 = a_1 - q_1$ in the domestic market and $p_2 = a_2 - q_2$ in the foreign market, and a linear labour input function $l = g(q) = q$. The revenue functions are: $R^1(q_1) = q_1(a_1 - q_1)$ for the domestic market and $R^2(q_2) = q_2(a_2 - q_2)$ for the foreign market. Furthermore we normalize the exchange rate to 1.

The system of first-order conditions (5)-(6) then is

$$a_1 - 2q_1 = \frac{(a_1 - q_1)q_1 + (a_2 - q_2)q_2 - K}{q_1 + q_2}, \tag{17}$$

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$$a_2 - 2q_2 = \frac{(a_1 - q_1)q_1 + (a_2 - q_2)q_2 - K}{q_1 + q_2}, \tag{18}$$

and can be rearranged and written in the following way (see Appendix B)

$$q_1^2 + q_2^2 = K, \tag{19}$$

$$q_1 - q_2 = \frac{1}{2}(a_1 - a_2). \tag{20}$$

From (20) we see that the greater the market (the higher a_i), the more is sold in this market. Moreover, direct computation shows that the optimal revenues are proportional to the sales in the markets:

$$\frac{R^1(q_1)}{R^2(q_2)} = \frac{q_1}{q_2}. \tag{21}$$

Thus, if the domestic market is greater than the foreign market[8] and the revenues from the domestic market are high enough to cover fixed costs, then a devaluation of the exchange rate leads to an increase in sales and a decrease in the price in the foreign market.

The change of total sales for the LMM is found to be equal to

$$\frac{dQ}{de} = \frac{1}{2g} \left[a_1 \frac{a_1 - a_2}{2} - 2K \right]. \tag{22}$$

The expression in brackets is positive if the domestic market is big and/or the difference between markets is high. Note that from (22) we can see that total production decreases if markets are of the same size ($a_1 = a_2$) or if the domestic market is smaller than the foreign one ($a_1 < a_2$).

We illustrate our example with Figure 4, which shows for which combinations of parameters a_1, a_2, and K we can expect specific reactions. On the horizontal line we indicate $m = (a_1 - a_2)/2$, which measures the difference between the size of markets. The parameter m should lie between $-\sqrt{K}$ and $\sqrt{K}$, otherwise the difference between markets is so large that the LMM abandons the smaller one and produces only

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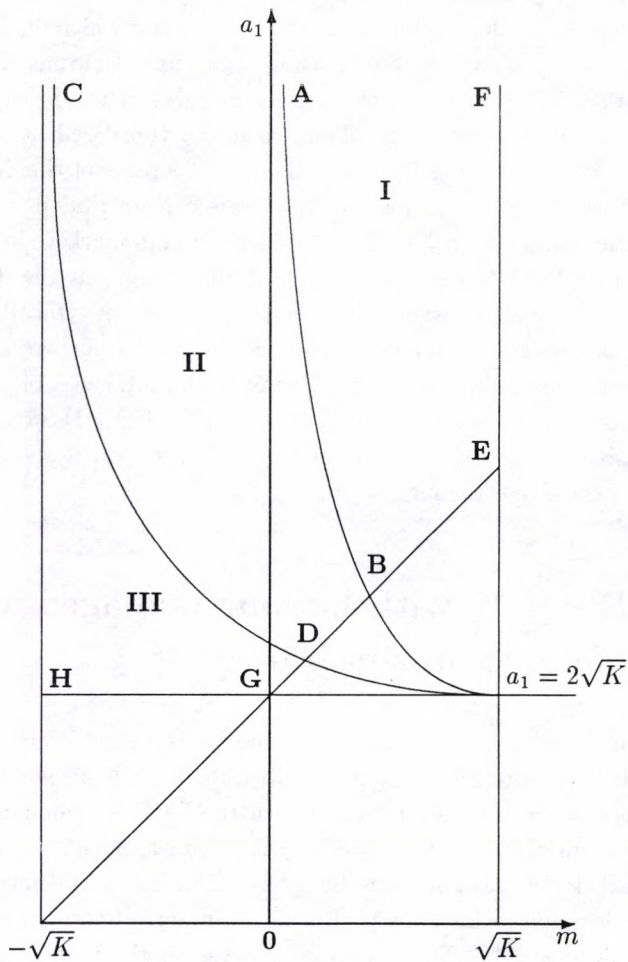[8]Note that transportation costs and trade restrictions reduce the size of the foreign market for the LMM.

Figure 4:

for the bigger one. We also assume that $a_1 > 2\sqrt{K}$ (line HG) and $m < a_1/2 - \sqrt{K}$ (line GE) which means that the LMM selling in only one market (foreign or domestic) can get a positive income per head. The curve AB represents the combination of parameters for which $dQ/de = 0$; above this curve total sales are increasing. The curve CD illustrates the case where $dq_2/de = 0$; above this curve the sales in the foreign market increase after a devaluation. Thus, in area I (bordered by ABEF), the increase of foreign sales is greater then the decrease of the domestic sales which results in an increase of total sales. Note that in this case the domestic market must be bigger than the foreign market. In area II (bordered by CDBA) foreign sales are still increasing, but the decrease in the domestic sales is larger. Note that this situation typically arises when the markets are equal and big enough. However it also arises when the foreign market is bigger but the size of both markets is big enough relative to the fixed costs. In area III (bordered by CDGH) foreign sales are decreasing. This is the case when the foreign market is significantly bigger than the domestic one.

3 A Duopoly with Labour-managed and Profit-maximizing Firms

The assumption about the LMF being a monopolist in the foreign market is restrictive. It often faces competition from foreign firms. For this reason, we now consider a model in which the LMF is a monopolist in the domestic market but faces competition from a foreign firm in the foreign market. We assume that the foreign firm is a profit-maximizing one and sells a good which is a perfect or an imperfect substitute to the good sold by the LMF. Thus, the model covers both the homogeneous good and product differentiation cases.

The income per head for the LMF given by (4) can be modified to

$$Y = \frac{R^1(q_1) + eR^2(q_2, q_2^*) - K}{g(q_1 + q_2)}, \tag{23}$$

where, as before, q_1, q_2 are quantities sold in the domestic and the foreign market respectively, and $g(q_1 + q_2) = l$ is a labour input function for the LMF with $g(0) = 0$, $g' > 0$, and $g'' \geq 0$. R^1, R^2 are the revenues functions from the domestic and foreign markets respectively. It is assumed that R^2 is concave with respect to q_2 and decreasing with respect to the competitor's sales q_2^*. Finally, K is a fixed cost and e is the exchange rate expressed in the domestic currency.

The profit function for the foreign PMF is

$$\Pi^* = R^*(q_2^*, q_2) - w^* g^*(q_2^*) - K^*, \tag{24}$$

where w^* is the foreign wage and variables with asterisks are associated with the foreign firm.

Assume that the labour-managed domestic firm maximizes its profit per unit of labour, while the foreign firm maximizes its profit and that the two firms use Cournot-Nash strategies. Under these conditions, we can derive the following first-order conditions:

$$Y_{q_1} = \frac{1}{g}(R_{q_1}^1 - g'Y) = 0, \tag{25}$$

$$Y_{q_2} = \frac{1}{g}(eR_{q_2}^2 - g'Y) = 0, \tag{26}$$

$$\Pi_{q_2^*}^* = R_{q_2^*}^* - w^* g^{*'} = 0. \tag{27}$$

From (25) and (26) the LMF still equalizes marginal revenues between markets, but their level is now influenced by the PMF's sales q_2^*. The second-order conditions require that $\Pi_{q_2^* q_2^*}^* < 0$ and that the matrix

$$\begin{bmatrix} Y_{q_1 q_1} & Y_{q_1 q_2} \\ Y_{q_2 q_1} & Y_{q_2 q_2} \end{bmatrix} \tag{28}$$

is negative-definite. We also impose a condition for stability, notably that the matrix

$$\begin{bmatrix} Y_{q_1 q_1} & Y_{q_1 q_2} & Y_{q_1 q_2^*} \\ Y_{q_2 q_1} & Y_{q_2 q_2} & Y_{q_2 q_2^*} \\ \Pi_{q_2^* q_1}^* & \Pi_{q_2^* q_2}^* & \Pi_{q_2^* q_2^*}^* \end{bmatrix} \tag{29}$$

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is N-P, i.e., it has all the principal minors of odd orders negative and those of even orders positive[9]. We will denote the 3×3 matrix from (29) by A. From the stability condition it follows that $\det A < 0$.

Total differentiation of Eqs. (25)-(27) gives the following comparative statics matrix equation:

$$A \begin{bmatrix} dq_1 \\ dq_2 \\ dq_2^* \end{bmatrix} = \begin{bmatrix} g'R^2/g \\ (g'R^2/g) - R_{q_2}^2 \\ 0 \end{bmatrix} de. \tag{30}$$

We are now in a position to evaluate the effect of a devaluation on duopolistic sales by solving system (30). We start with the foreign sales of the LMF. From (30) we obtain

$$\frac{dq_2}{de} = \underbrace{\frac{\Pi_{q_2^* q_2^*}^*}{\det A}}_{(+)} \left\{ \underbrace{Y_{q_1 q_1}[(g'R^2/g) - R_{q_2}^2]}_{(-)} + \underbrace{g'g''R^2Y/g}_{(+)} \right\}. \tag{31}$$

If we compare (31) with the reaction of the LMM described by (11), we see that the expressions are similar. In particular if the value

$$-[(g'R^2/g) - R_{q_2}^2] = \frac{1}{eg}(R^1 - K) \tag{32}$$

is positive then the LMF increases foreign sales after a devaluation. Hence, this problem is equivalent to the one of the LMM, so there is no need to repeat the analysis here.

From (30) we get for the domestic sales of the PMF

$$\frac{dq_2^*}{de} = \frac{\Pi_{q_2^* q_2}^*}{\det A} \{ -Y_{q_1 q_1}[(g'R^2/g) - R_{q_2}^2] - g'g''R^2Y/g \}. \tag{33}$$

Moreover, (31) and (33) imply that

$$\frac{dq_2^*}{de} \bigg/ \frac{dq_2}{de} = \frac{-\Pi_{q_2^* q_2}^*}{\Pi_{q_2^* q_2^*}^*}. \tag{34}$$

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[9]This terminology is due to Nikaido (1968, p.361) and stands for the "negative-positive" signs of the principal minors.

Thus, if $\Pi_{q_2^* q_2} < 0$, that is, if the PMF treats the good as a strategic substitute[10] then its sales move in the opposite direction to those of the LMF. This is a standard result in the literature[11]. However, in these models the LMF always *decreases* sales in the foreign market when facing an upward shift of the foreign market demand curve. In our model, to the contrary, the multimarket LMF can increase production when facing such a shift.

For the domestic sales of the LMF, from (30) we obtain,

$$
\frac{dq_1}{de} = \overbrace{\frac{1}{\det A}}^{(-)} \Bigg\{ (g'R^2/g) \overbrace{\begin{bmatrix} Y_{q_2 q_2} & Y_{q_2 q_2^*} \\ \Pi^*_{q_2^* q_2} & \Pi^*_{q_2^* q_2^*} \end{bmatrix}}^{(+)}
\tag{35}
$$
$$
+ \left[(g'R^2/g) - R_{q_2}^2 \right] \Big[\underbrace{g''Y\Pi^*_{q_2^* q_2^*}}_{(-)} - \underbrace{g'Y_{q_2^*}\, \Pi^*_{q_2^* q_2}}_{(-)} \Big] \Bigg\}.
$$

(35) shows that when the PMF treats the good as a strategic substitute $(\Pi_{q_2^* q_2} < 0)$ and when expression $(g'R^2/g) - R_{q_2}^2$ is negative, then the LMF decreases production in the domestic market after a devaluation.

We can sum up our results in the following proposition.

Proposition 1 *If*

(a) *in a Cournot-Nash equilibrium the LMF revenues in the domestic market are high enough to cover fixed costs $(R^1 - K > 0)$ and*

(b) *the PMF treats the good as a strategic substitute $(\Pi_{q_2^* q_2} < 0)$,*

then a devaluation of the domestic currency (an increase of e) leads to

(i) *an increase in foreign sales and a decrease in domestic sales for the LMF and*

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[10]This is a widely used assumption in a Cournot oligopoly with profit maximizing firms. However, strategic complementarity $(\Pi_{q_2^* q_2} > 0)$ can emerge as a result of natural demand and cost structures. For more details see Bulow et al. (1985) and Baniak-Phlips (1995).

[11]See, for instance, Mai and Hwang (1989) and Okuguchi (1993).

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(ii) *a decrease in sales for the foreign PMF.*

If there is more than one foreign competitor of the LMF then devaluation becomes a more effective tool of export promotion. The underlying intuition is as follows. If there are more profit-maximizing competitors in the foreign market, then the total sales of foreign firms will be higher in a Cournot-Nash equilibrium and the residual revenue of the LMF in the foreign market shifts downward. From Section 2 we know that if the revenue from one market increases, then the sales in the second market decrease. Analogously, the LMF will react to a downward shift of foreign revenues by increasing domestic sales. Thus, from Figure 1, it is more likely that the revenues from the domestic market will cover fixed costs.

4 The Effects of an Export Subsidy

To consider the effect of an export subsidy to the LMF we need to modify our model slightly. Let s be an export subsidy per unit of foreign sales. Then the revenues of the LMF from the foreign market are

$$R^2(q_2, s) = q_2 p_2(q_2) + q_2 s, \tag{36}$$

and the income per head for the LMM is

$$Y = \frac{R^1(q_1) + R^2(q_2, s) - K}{g(q_1 + q_2)}. \tag{37}$$

Analogous computations to those in section 2 show that

$$\frac{dq_1}{ds} = \overbrace{\frac{1}{\det H}}^{(+)} \left[\overbrace{R^2_{q_2 q_2}}^{(-)} \overbrace{(g' q_2 / g)}^{(+)} - \overbrace{g'' Y}^{(+)} \right] < 0, \tag{38}$$

$$\frac{dq_2}{de} = \underbrace{\frac{1}{\det H}}_{(+)} \left\{ \underbrace{Y_{q_1 q_1}}_{(-)} [(g' q_2 / g) - 1] + \underbrace{g' g'' q_2 Y / g}_{(+)} \right\}. \tag{39}$$

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From (38) and (39) we see that, assuming $Y > 0$, an increase in the export subsidy leads the LMM to a decrease in domestic sales. If $g'q_2/g < 1$, then the LMM increases its foreign sales[12].

Using the fact that the input-labour function g is inverse to the production function f we can write

$$\frac{g'(q_1 + q_2)q_2}{g(q_1 + q_2)} = \frac{q_2}{(l_1 + l_2)f'(l_1 + l_2)} = \frac{q_2 f(l_1 + l_2)}{(l_1 + l_2)f'(l_1 + l_2)(q_1 + q_2)} = \frac{\alpha_2}{\epsilon_f}, \tag{40}$$

where $\alpha_2 = q_2/(q_1 + q_2) < 1$ is the ratio of foreign sales to total sales for the LMM and $\epsilon_f = f'l/f < 1$ is the elasticity of the production function. Thus, if the elasticity of the production function is higher than the proportion of foreign sales in total sales, then the LMM increases its foreign sales after the introduction of the export subsidy. In particular, if f is a constant elasticity production function $f(l) = l^\beta$, $0 < \beta < 1$ then $\epsilon_f = \beta$ and for a low enough proportion of foreign sales ($\alpha_2 < \beta$) we can expect an increase in foreign sales. This illustrates that the crucial point here is the high ratio of the domestic sales in total sales, as with the devaluation case. Thus, if the multimarket LMF sells mainly at home, the introduction of an export subsidy can be an effective tool for promoting exports.

Generally, the elasticity of the production function ϵ_f measures the degree of returns to scale: the higher ϵ_f, the higher the degree of returns to scale from labour. Rearranging (39) and using identity (8) we obtain

$$\frac{dq_2}{de} = \underbrace{\frac{1}{\det H}}_{(+)} (\underbrace{R^1_{q_1 q_1} \frac{\alpha_2}{\epsilon_f}}_{(-)} - \underbrace{Y_{q_1 q_1}}_{(-)}). \tag{41}$$

From (41) we see that *ceteris paribus* dq_2/de increases with an increase in ϵ_f. In other words: the higher the degree of returns to scale from labour, the more the LMF will sell in the foreign market after the introduction of the export subsidy. It is obvious that the PMF would react similarly in the same situation.

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[12]It is easy to show that the same condition emerges when the LMF is a price-taker in the foreign market, i.e., $R^2(q_2, s) = p_2 q_2 + q_2 s$.

All that has been said about the LMM can be extended to a duopoly with the domestic LMF selling at home and abroad and the foreign PMF selling only at home. Thus, we can extend the results of Mai and Hwang (1989) and Okuguchi (1991). In particular we can show that the LMF selling at home and abroad can increase foreign sales after a small increase in the export subsidy, a possibility which was not considered by these authors.

If the LMF faces more competition in the foreign market, then, analogously to section 3, it increases sales in the domestic market. In this case the export subsidy becomes a more effective tool for promoting exports.

Welfare Effects

We now evaluate the welfare effects of the introduction of an export subsidy in the domestic country. This is done by considering the impact of changes in s on the net-consumer surplus $Z^1(p_1)$ in the domestic country, on the subsidy losses sq_2 and on the profits Π of the LMM. Following Amis and Ross (1992) we can see that the effect on welfare W^1 in the domestic country will be

$$\frac{dW^1}{ds} = \frac{dZ^1}{dp_1}\frac{dp_1}{ds} - s\frac{dq_2}{ds} - q_2 + \frac{d\Pi}{ds}. \qquad (42)$$

Evaluating (42) at $s = 0$ and given that $dZ^1/dp_1 = -q_1$ we find that

$$\frac{dW^1}{ds} = -q_1\frac{dp_1}{ds} - q_2 + \frac{d\Pi}{ds}. \qquad (43)$$

After some manipulation (see Appendix C) we can simplify (43) to

$$\frac{dW^1}{ds} = -q_1\frac{dp_1}{ds} + \Pi\frac{g'}{g}\frac{dQ}{ds}. \qquad (44)$$

The first term in (44) is always negative and measures consumer losses connected with an increase in price in the domestic country. The second term in (44) measures the net effect on the profits of the LMM. If the

total output of the LMM increases after the introduction of an export subsidy ($\mathrm{d}Q/\mathrm{d}s > 0$) and the optimal level of profits of the LMM is positive and high enough, then the second term in (44) can outweigh the first one and the welfare effect may be positive[13].

Coming back to the linear example from section 2 we see that $g'q_2/g = q_2/Q$ and is less than 1. Thus, the LMM will always increase sales in the foreign market. This stems from the fact that the degree of returns to scale for linear production function $f(l) = l$ is equal to 1, the highest possible value.

The change of total sales is

$$\frac{\mathrm{d}Q}{\mathrm{d}s} = \frac{1}{2}\frac{q_1 - q_2}{Q}, \tag{45}$$

and is positive only if domestic sales exceed foreign sales. Rearranging (44) and performing some algebra (see Appendix C) we obtain

$$\frac{\mathrm{d}W^1}{\mathrm{d}s} = \frac{1}{4q}\left[m\left(2a_1 - m - 2w - \sqrt{2K - m^2} - \frac{2K}{\sqrt{2K - m^2}}\right) - K\right], \tag{46}$$

where, as before, $m = (a_1 - a_2)/2$. Equation $\mathrm{d}W^1/\mathrm{d}s = 0$ defines a_1 as a function of m. For all combinations of a_1 and m which lie above the curve $\mathrm{d}W^1/\mathrm{d}s = 0$, welfare will increase after the introduction of an export subsidy. This situation is illustrated in Figure 5. The curve AB represents the equation $\mathrm{d}W^1/\mathrm{d}s = 0$. Above this curve (region I) welfare increases, below this curve (region II) welfare decreases.

We see from figure 5 that an increase in welfare is assured when the domestic market is bigger than the foreign one ($a_1 > a_2$) and when markets are large enough compared with fixed costs (K) and the wage level

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[13]It is interesting to note that the introduction of an export subsidy for the PMF in an analogous situation leads to welfare losses. In this case, from the envelope condition, we have $\mathrm{d}\Pi/\mathrm{d}s = q_2$ and from (43) it follows

$$\frac{\mathrm{d}W^1}{\mathrm{d}s} = -q_1\frac{\mathrm{d}p_1}{\mathrm{d}s}.$$

Thus, if the PMF exhibits diseconomies of scale, then it decreases sales and increases the price in the domestic market and we have a welfare loss. With economies of scale welfare increases.
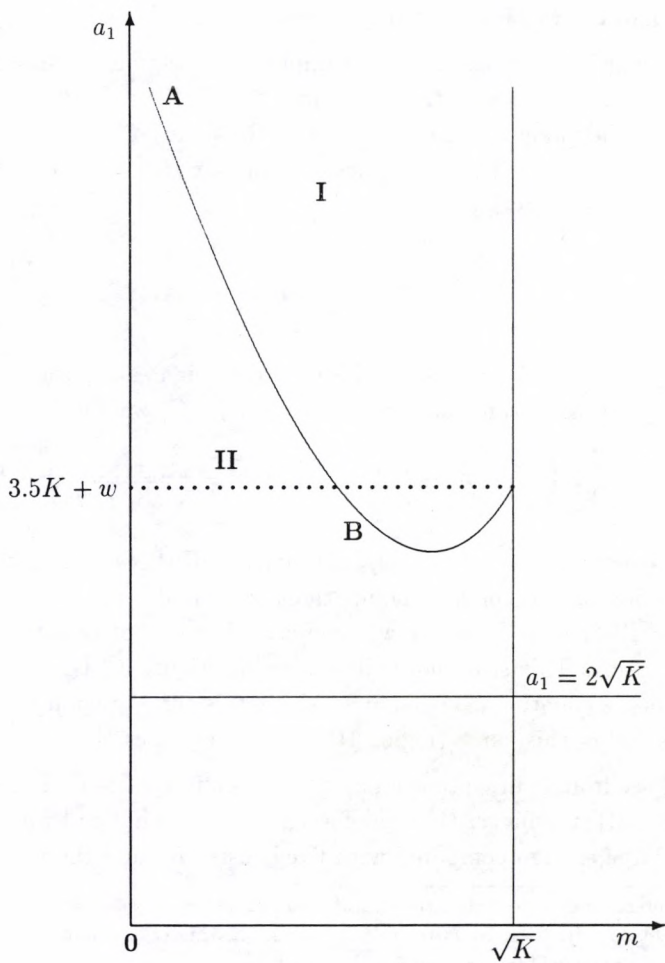
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Figure 5:

(w). In this case the LMM makes high profits before the introduction of an export subsidy. The increase in sales in the foreign market after an export subsidy is such that the increase in profits in the foreign market outweighs the consumer losses in the domestic market and the decrease in profits in the domestic market.

5   Conclusions

We have shown that for a LMF which sells in the foreign and domestic markets a devaluation of the domestic currency can lead to an increase in exports, a reaction which can not occur when the LMF sells only in the foreign market. The LMF will increase exports after a devaluation when the sales in the domestic market are high enough or, equivalently, when the revenues from the domestic market are high enough to cover fixed costs.

A similar effect – an increase in exports – can occur when the multimarket LMF receives a small export subsidy. This will happen if the sales in the foreign market are relatively small and/or the productivity of labour (measured by the degree of returns of scale) is low.

These results are related to work of Krugman (1984) who showed that in a duopolistic multimarket model with economies of scale, the introduction of import protection (in the form of quotas or tariffs) will lead to an increase in exports. In other words import protection implies export promotion[14]. Using the results from Section 2, we can analyze the same problem for the LMF. Consider an LMF which sells in the domestic and foreign markets and faces foreign competition in the domestic market. The introduction of import protection leads to a decrease in sales for the foreign firm and to an upward shift of the residual domestic demand for the LMF. According to the results from Section 2, the LMF

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[14]Krugman assumed strategic substitutability among the duopolists. If we assume strategic complementarity and diseconomies of scale, then the introduction of import protection leads to a decrease in exports. Such a result can be easily obtained from Prop.4 in Baniak and Phlips (1995).

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will always react by contracting its exports and the change in sales in the domestic market is ambiguous and depends on the relative size of the markets. Thus, for the LMF, import protection always implies a decrease in exports, although it can lead to an increase in domestic sales.

Throughout the paper we assumed that the LMF is a monopolist in the domestic market. Of course this assumption could be relaxed. For example, if the LMF meets competition in its home market, the effects of a devaluation or an export subsidy will be the same as when it is a monopolist in its domestic market. This stems from the fact that the domestic competitors react indirectly to a devaluation and therefore adjust only to the direct reaction of the LMF to a devaluation. The situation becomes more complicated for a duopoly with both the LMF and the PMF selling at home and abroad. In this case the PMF will sell less in its foreign market after a devaluation and this direct effect will influence the change in the sales of the LMF[15]. Such a model for two PMF was analyzed by Kirman and Phlips (1991), Hens, Kirman and Phlips (1992) and Baniak and Phlips (1995) and the results depend heavily on the kind of strategic interaction between duopolists (strategic substitutability or complementarity) and on the kind of economies of scale assumed.

Appendix

A. Positive Marginal Revenues per Worker

From (14) we know that (assuming $e = 1$)

$$\text{MRW}_2' = \frac{R_{q_2}^2 g(q_1^* + q_2) - g'(q_1^* + q_2)R^2}{g^2(q_1^* + q_2)} = q_2 \frac{R_{q_2}^2 \frac{g(q_1^* + q_2)}{q_2} - g'(q_1^* + q_2)\frac{R^2}{q_2}}{g^2(q_1^* + q_2)}. \tag{A.1}$$

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[15]In such a situation the LMF faces an increase in revenues in the foreign market (as a result of the devaluation) and an increase in revenues in the domestic market (because the foreign PMF contracted its exports). It is not clear what the reaction of the LMF will be.

From the concavity of the revenue function R^2 we know that marginal revenue is lower than average revenue or

$$R^2_{q_2} < R^2/q_2. \tag{A.2}$$

If the LMM operates on one, namely the foreign, market, then $q^*_1 = 0$. From the assumption of diminishing returns from labour we conclude that average labour input is lower than marginal labour input, in other words

$$g(q_2)/q_2 < g'(q_2). \tag{A.3}$$

From (A.2) and (A.3) we obtain that the numerator of the expression on the right hand side of (A.1) is negative, thus the marginal revenues per worker are always negative.

If the LMM operates on two markets then $q^*_1 > 0$ and the average labour input $g(q^*_1 + q_2)/q_2$ is high for small values of q_2, in particular $\lim_{q_2 \to 0} g(q^*_1 + q_2)/q_2 = +\infty$. Hence, we can conclude that for small values of q_2 the marginal revenues per worker are positive.

B. Linear Example

If $R^i = q_i(a_i - q_i)$ and $g(q) = q$ then the first-order conditions (5) and (6) are

$$a_1 - 2q_1 = \frac{q_1(a_1 - q_1) + q_2(a_2 - q_2) - K}{q_1 + q_2}, \tag{B.1}$$

$$a_2 - 2q_2 = \frac{q_1(a_1 - q_1) + q_2(a_2 - q_2) - K}{q_1 + q_2}. \tag{B.2}$$

After some manipulation we obtain from (B.1) and (B.2) Eqs. (19) and (20).

By solving directly the system of equations (19) and (20) we get

$$q_1 = \frac{1}{2}\left(m + \sqrt{2K - m^2}\right), \tag{B.3}$$

$$q_2 = \frac{1}{2}\left(-m + \sqrt{2K - m^2}\right), \tag{B.4}$$

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where $m = (a_1 - a_2)/2$. Both outputs q_1 and q_2 will be nonnegative iff $-\sqrt{K} \le m \le \sqrt{K}$.

From (B.3) and (B.4) we have

$$a_1 - q_1 = a_2 - q_2 = \frac{1}{2}\left(a_1 + a_2 - \sqrt{2K - m^2}\right), \qquad (B.5)$$

and from (B.5) we get Eq. (21).

From (10), (11), (B.3) and (B.4) we get

$$\frac{dQ}{de} = \frac{1}{2}\left[a_2 - 2q_2 - \frac{2q_2(a_2 - q_2)}{q_1 + q_2}\right]. \qquad (B.6)$$

After some computations, we obtain Eq. (22).

From Eqs. (21) and (11) we know that for a_1 which lies above the line

$$q_1(a_1 - q_1) - K = 0, \qquad (B.7)$$

the LMM will increase its foreign sales after a devaluation. Equation (B.7) defines a_1 as a function of q_1:

$$a_1 = \frac{K}{q_1} + q_1 \qquad (B.8)$$

The function (B.8) decreases from $+\infty$ to $2\sqrt{K}$ (as q_1 changes from 0 to $\sqrt{K}$) and is convex. Equation (B.3) defines q_1 as an increasing function of m which has values $0, \frac{\sqrt{2}}{2}\sqrt{K}$ and $\sqrt{K}$ for m equal to $-\sqrt{K}, 0$ and $\sqrt{K}$ respectively. Thus, the composition of functions (B.3) and (B.8) gives us a_1 as a function of m which is convex and increasing and has values $+\infty, \frac{3\sqrt{2}}{2}\sqrt{K}$ and $2\sqrt{K}$ for m equal to $-\sqrt{K}, 0$ and $\sqrt{K}$ respectively. This is the curve CD in Figure 4.

C. Welfare Effects of Export Subsidy

We now derive formula (44). To evaluate $d\Pi/ds$ we find from (1)

$$\Pi = (Y - w)g, \qquad (C.1)$$

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and

$$\frac{d\Pi}{ds} = g\frac{dY}{ds} + (Y - w)\frac{dg}{ds}. \tag{C.2}$$

An envelope condition tells us that $dY/ds = q_2/g$ and thus $dg/ds = g'dQ/ds$. So, we can simplify (C.2) to

$$\frac{d\Pi}{ds} = q_2 + \Pi\frac{g'}{g}\frac{dQ}{ds}. \tag{C.3}$$

Substituting (C.3) into (43) yields (44).

Now we can compute the formula (46) from the linear example. From (38) we obtain

$$\frac{dq_1}{ds} = -\frac{1}{2}\frac{q_2}{Q}. \tag{C.4}$$

Substituting (45), (C.5) into (44) and rearranging the terms we get

$$\frac{dW_1}{ds} = \frac{1}{2Q}\left(\frac{q_1 - q_2}{Q}\Pi - q_1 q_2\right). \tag{C.5}$$

The optimal level of profits Π is

$$\Pi = q_1(a_1 - q_1) + q_2(a_2 - q_2) - wQ - K, \tag{C.6}$$

which, by (B.5), is equal to

$$\Pi = \frac{1}{2}\left(a_1 + a_2 - 2w - \sqrt{2K - m^2}\right)Q - K. \tag{C.7}$$

From (B.3), (B.4) we get

$$q_1 q_2 = \frac{1}{2}(K - m^2) \quad \text{and} \quad Q = \sqrt{2K - m^2}. \tag{C.8}$$

Substituting (C.7) and (C.8) into (C.5) and rearranging terms yields (46).

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