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Transportation rates, monopsony power and the location decision of the firm

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Abstract

This paper investigates the impact of monopsony power on the location decision of the firm. It shows that if the transportation rates are a function of distance only and the production function is homogeneous of degree one, the optimum location is independent of monopsony power. However, if the transportation rates are a function of quantity shipped and distance traveled, a homogeneous production of degree one does not ensure independence between the optimum location and monopsony power. This result is significantly different from the well−known Mai−Suwanakul−Yeh proposition in the constant transportation case.

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1. Introduction

In recent years a large number of studies have attempted to integrate location theory with neoclassical production theory. Most of these studies, following the pioneering work of Moses (1958), assume that the input markets are perfectly competitive and show that the optimum location of the firm is independent of the demand function if the production function is homogenous of degree one (see Martinich and Hurter 1990). Little attention was devoted to the monopsony case. Recently Mai, Suwanskul and Yeh (1993) (henceforth MSY) incorporated the monopsony market structure into the one-output, two-input Weber-Moses triangle and attempted to fill this gap. Assume that (i) the production function is homogenous of degree N; (ii) transportation rates are constant; (iii) the firm is a price taker in the output market and one input market, but is a monopsonist in another input market. They examined the impact of monopsony power on the location decision of the firm and obtained the following interesting and important proposition.

MSY. The optimum location of the firm is independent of monopsony power if the production function is homogeneous of degree one. (MSY 1993, propositions 1 and 2).

This result crucially depends upon the constant transportation rates assumption. However, it is well known that in transportation economics, discounts for quantity shipped and distance traveled are prevalent among various modes of transportation (see Fair and Williams 1975, Miller and Jensen 1978, Shieh and Mai 1984, Stahl 1987). It would be interesting and important to examine the impact of monopsony power on the location decision of the firm if transportation rates are a function of quantity shipped and distance traveled.

The purpose of this paper is to incorporate quantity and distance discounts as key variables into the transportation rate functions and to examine the impact of monopsony power on the location decision. It will be shown that the location decision of the firm is not independent of the monopsony power if the production function is homogeneous of degree one. This result indicates that MSY's proposition in general fails to apply.

2. The monopsonistic location model

In order to investigate the connections between transportation rates, monopsony power and location decisions, we use a model defined by a number of basic assumptions that will characterize much of our analysis.

(A1) A firm employs two transportable inputs (L and K) located at A and B to produce a single output (Q) which is sold in the output market C. The location triangle in Figure 1 illustrates the location problem of the firm. In Figure 1, the distances a and b and the angle $\pi/2 > \alpha > 0$ are given.

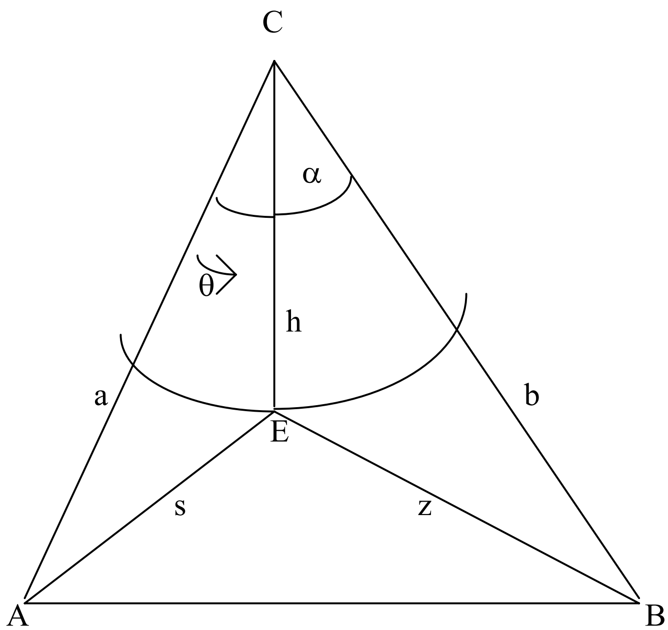

Figure 1. Location Triangle

(A2) The homogeneous production function of degree N is specified as:

$$Q = f(L, K),\ f_L > 0,\ f_K > 0,\ f_{LK} = f_{KL} > 0,\ f_{LL} < 0,\ f_{KK} < 0 \qquad (1)$$

and $f_L L + f_K K = NQ$, $f_{LL} L + f_{LK} K = (N\text{-}1)f_L$, $f_{KL} L + f_{KK} K = (N\text{-}1)f_K$, $f_{LL} L^2 + 2f_{LK} LK + f_{KK} K^2 = N(N\text{-}1)Q$. Note that subscripts are used for partial derivatives throughout the paper.

(A3) The transportation rate functions for inputs and output are specified as:

$$n = n(s, L),\ \ m = m(z, K),\ \ t = t(h, Q) \qquad (2)$$

where n, m and t are transportation rates of L, K, and Q; s, z and h are distances from the plant to the sources A, B and the output market C. $n_s < 0$, $m_z < 0$, $t_h < 0$, $n_L < 0$, $m_K < 0$, and $t_Q < 0$. By the law of cosines, we can express s and z as:

$$s = (a^2 + h^2 - 2ah\cos\theta)^{1/2},\ \ z = [b^2 + h^2 - 2bh\cos(\alpha\text{-}\theta)]^{1/2} \qquad (3)$$

(A4) The prices of inputs and output are evaluated at the firm's location E. The costs of purchasing inputs (L and K) at the plant are the prices of inputs at sources (w and r) plus the full freight costs (ns and mz), i.e., w + ns and r + mz. The price of output at the plant is the market price (p) minus the freight cost (th), i.e., p - th.

(A5) The firm is a price taker in the output market and the input K market, but has monopsony power in the input L market (see Yeh, Mai and Shieh 1996). It faces an upward sloping input supply curve w(L) with $w_L > 0$. According to Lerner (1934), Bronfenbrenner (1971), the degree of monopsony power can be measured by the elasticity of input supply, $e \equiv (dL/dw)(w/L) = (1/w_L)(w/L)$ with $0 < e < \infty$. If $e \to \infty$, the input L market is perfectly competitive and monopsony does not exit. It may be noted that the lower is the value of e, the higher is the monopsony power.

(A6) The objective of the firm is to choose the optimum location within the triangle that maximizes the profit.

It should be noted that the inclusion of (A3) constitutes a major departure from MSY. That is, instead of assuming constant transportation rates, we now permit these rates to vary with quantity shipped and distance traveled.

With this set of assumptions, the profit-maximizing location problem can be formulated as:

$$\text{Max } \pi = (p\text{-}th)f(L,K) - [w(L) + ns]L - (r + mz)K \qquad (4)$$

where L, K, θ and h are choice variables. The first-order conditions are

$$(\partial\pi/\partial L) = (p\text{-}thu)f_L - \{w[1+(1/e)] + nsu_L\} = 0 \qquad (5)$$
$$(\partial\pi/\partial K) = (p\text{-}thu)f_K - (r + mzu_K) = 0 \qquad (6)$$
$$(\partial\pi/\partial\theta) = -ns_\theta v_L L - mz_\theta v_K K = 0 \qquad (7)$$
$$(\partial\pi/\partial h) = -tvQ - ns_h v_L L - mz_h v_K K = 0 \qquad (8)$$

where $u \equiv 1 + c$, $u_L \equiv 1 + c_L$, $u_K \equiv 1 + c_K$, $v \equiv 1 + d$, $v_L \equiv 1 + d_L$, $v_K \equiv 1 + d_K$, $c \equiv t_Q(Q/t) < 0$, $c_L \equiv n_L(L/n) < 0$ and $c_K \equiv m_K(K/m) < 0$ are the elasticity of transportation rates with respect to output and inputs; $d \equiv t_h(h/t) < 0$, $d_L \equiv n_s(s/n) < 0$ and $d_K \equiv m_z(z/m) < 0$ are the elasticity of transportation rates with respect distances h, s and z. Following Miller and Jensen (1978), we assume that the elasticity of transportation rates, c, c_L, c_K, d, d_L, and d_K are constant, and u, u_L, u_K, v, v_L, are v_K are positive throughout the paper. Assume also that e is a parameter.

We can solve (5) - (8) for L, K, θ, and h in terms of e, r, p, a, b and α if the second-order conditions are satisfied. This completes the monopsonistic location model that comprises the basic analytical framework.

3. The impact of monopsony power on location

We are now in a position to examine the effects of a change in monopsony power on the production-location decision. Applying the standard comparative static procedures to (5) - (8), we obtain

$$\partial\theta/\partial e = (E/KD)(F + G) \qquad (9)$$
$$\partial h/\partial e = (E/KD)(H + I) \qquad (10)$$

where

$$E \equiv (w/e^2) > 0 \qquad (11)$$

$$F = (p\text{-}thu)(N\text{-}1)f_K(\pi_{\theta L}\pi_{hh} - \pi_{\theta h}\pi_{hL}) + tQvu_K[N(u/u_K)\text{-}1](\pi_{\theta L}\pi_{Kh} - \pi_{KL}\pi_{\theta h}) \quad (12)$$

$$G = nv_L Lu_K[(u_L/u_K)\text{-}1][s_h(\pi_{\theta L}\pi_{Kh} - \pi_{KL}\pi_{\theta h}) + s_\theta(\pi_{KL}\pi_{hh} - \pi_{Kh}\pi_{hL})] + [thf_K Nu(u\text{-}1) + mzKu_K(u_K\text{-}1)](\pi_{\theta h}\pi_{hL} - \pi_{\theta L}\pi_{hh}) \quad (13)$$

$$H = (p\text{-}thu)(N\text{-}1)f_K(\pi_{\theta\theta}\pi_{hL} - \pi_{\theta L}\pi_{h\theta}) + tQvu_K[N(u/u_K)\text{-}1](\pi_{KL}\pi_{\theta\theta} - \pi_{K\theta}\pi_{\theta L}) \quad (14)$$

$$I = nv_L Lu_K[(u_L/u_K)\text{-}1][s_\theta(\pi_{K\theta}\pi_{hL} - \pi_{KL}\pi_{h\theta}) + s_h(\pi_{KL}\pi_{\theta\theta} - \pi_{K\theta}\pi_{\theta L})] + [thf_K Nu(u\text{-}1) + mzKu_K(u_K\text{-}1)](\pi_{\theta L}\pi_{h\theta} - \pi_{\theta\theta}\pi_{hL}) \quad (15)$$

and $D > 0$ by the second-order conditions. The expressions of π_{ij} and e_{ij} (i,j = L, K, θ, h) would be: $\pi_{LL} = (p\text{-}thu)f_{LL} - w_L[1+(1/e)] - e_{LL}$, $\pi_{LK} = \pi_{KL} = (p\text{-}thu)f_{LK} - e_{LK}$, $\pi_{L\theta} = \pi_{\theta L} = -ns_\theta v_L u_L$, $\pi_{Lh} = \pi_{hL} = -(tf_L vu + ns_h v_L u_L)$, $\pi_{KK} = (p\text{-}thu)f_{KK} - e_{KK}$, $\pi_{K\theta} = \pi_{\theta K} = -mz_\theta v_K u_K$, $\pi_{Kh} = \pi_{hK} = -tf_K vu - mz_h v_K u_K$, $\pi_{\theta\theta} = -(ns_{\theta\theta} v_L L + mz_{\theta\theta} v_K K) - e_{\theta\theta}$, $\pi_{\theta h} = \pi_{h\theta} = -(ns_{\theta h} v_L L + mz_{\theta h} v_K K) - e_{\theta h}$, $\pi_{hh} = -(ns_{hh} v_L L + mz_{hh} v_K K) - e_{hh}$, $e_{LL} \equiv (t/Q)hf_L^2 cu + (n/L)sc_L u_L$, $e_{LK} \equiv (t/Q)hf_L f_K cu$, $e_{KK} \equiv (t/Q)hf_K^2 cu + (m/K)zc_K u_K$, $e_{\theta\theta} \equiv (n/s)s_\theta^2 d_L v_L L + (m/z)z_\theta^2 d_K v_K K$, $e_{\theta h} \equiv (n/s)s_\theta s_h d_L v_L L + (m/z)z_\theta z_h d_K v_K K$, $e_{hh} \equiv (t/h)dvQ + (n/s)s_h^2 d_L v_L L + (m/z)s_h^2 d_K v_K K$. Note that (i) if the transportation rates are independent of quantity shipped, $c = c_L = c_K = 0$, $u = u_L = u_K = 1$, $e_{LL} = e_{LK} = e_{KK} = 0$; (ii) if the transportation rates are independent of distance traveled, $d = d_L = d_K = 0$, $v = v_L = v_K = 1$ and $e_{\theta\theta} = e_{\theta h} = e_{hh} = 0$. It is of interest to note that, to derive (12)-(15), we use the first-order conditions, $-mz_\theta v_K K = ns_\theta v_L L$, $-mz_h v_K K = tvQ + ns_h v_L L$, and the property of homogeneous function of degree N, $f_K K + f_L L = NQ$.

It is clear that in (9) and (10) the signs of F, G, H and I can not be determined *a priori*. Thus, we can conclude that the impact of monopsony power on the optimum location is ambiguous.

Next, we turn to the case in which the production function is homogeneous of degree one, i.e., N = 1. Assuming that the elasticity of transportation rates with respect to quantity shipped and distance traveled are constant, we examine three specific situations: (1) transportation rates are constant; (2) transportation rates are a function of distance traveled; (3) transportation rates are a function of quantity shipped and distance traveled.

3.1. Transportation rates are constant

In this case, $v = v_L = v_K = u = u_L = u_K = 1$, and then $G = I = 0$. Thus, (9) and (10) can be rewritten as:

$$\partial\theta/\partial e = (E/KD)(N\text{-}1)[(p\text{-}th)f_K(\pi_{\theta L}\pi_{hh} - \pi_{\theta h}\pi_{hL}) + tQ(\pi_{\theta L}\pi_{Kh} - \pi_{KL}\pi_{\theta h})] \quad (9a)$$

$$\partial h/\partial e = (E/KD)(N\text{-}1)[(p\text{-}th)f_K(\pi_{\theta\theta}\pi_{hL} - \pi_{\theta L}\pi_{h\theta}) + tQ(\pi_{KL}\pi_{\theta\theta} - \pi_{\theta L}\pi_{K\theta})] \quad (10a)$$

It is clear that $\partial\theta/\partial e = 0$ and $\partial h/\partial e = 0$ if N = 1. In other words, if the production function is homogeneous of degree one, the optimum location of the monopsonistic firm is independent of monopsony power. This is MSY's case.

3.2. Transportation rates are a function of distance

In this case, $1 > v > 0$, $1 > v_L > 0$, $1 > v_K > 0$, $u = u_K = u_L = 1$, and then $G = I = 0$. The expressions in (9) and (10) become

$$\partial\theta/\partial e = (E/KD)(N-1)(p-th)f_K(\pi_{\theta L}\pi_{hh}-\pi_{\theta h}\pi_{hL}) + tQv(\pi_{\theta L}\pi_{Kh}-\pi_{\theta h}\pi_{KL}) \quad (9b)$$
$$\partial h/\partial e = (E/KD)(N-1)(p-th)f_K(\pi_{\theta\theta}\pi_{hL}-\pi_{\theta L}\pi_{h\theta}) + tQv(\pi_{KL}\pi_{\theta\theta}-\pi_{\theta L}\pi_{K\theta}) \quad (10b)$$

It is easy to see that $\partial\theta/\partial e = 0$ and $\partial h/\partial e = 0$ if $N = 1$. In other words, if the production function is homogeneous of degree one and the transportation rates are a function of distance only, the optimum location of the monopsonistic firm is independent of monopsony power.

This result generalizes MSY's proposition since we have not assumed constant transportation rates. It is well known that in the Weberian location theory (see Weber 1929, p. 78), the optimum location is found by considering the relative strength of three forces: the market pull and two material pulls. Each force is comprised of the quantity and marginal transportation cost components. If N = 1 and the transportation rates are a function of distance only, a change in monopsony power will not change the mix of output and inputs, and the relative transportation costs. Therefore, the relative pulls of the output and the inputs are unaffected, and the optimum location is independent of monopsony power.

3.3. Transportation rates are a function of quantity and distance

In this case, $1 > u > 0$, $1 > u_K > 0$, $1 > u_L > 0$, $1 > v > 0$, $1 > v_K > 0$ and $1 > v_L > 0$. If $N = 1$, the expressions in (9) and (10) become

$$\partial\theta/\partial e = (E/DK)\{tQvu_K[N(u/u_K)-1](\pi_{\theta L}\pi_{Kh}-\pi_{KL}\pi_{\theta h})+G\} \quad (9c)$$
$$\partial h/\partial e = (E/DK)\{tQvu_K[N(u/u_K)-1](\pi_{KL}\pi_{\theta\theta}-\pi_{K\theta}\pi_{\theta L})+I\} \quad (10c)$$

Since the signs of $\partial\theta/\partial e$ and $\partial h/\partial e$ are not equal to zero, we can conclude that if the transportation rates are a function of quantity shipped and distance traveled, a homogeneous production function of degree one is not sufficient to ensure that the optimum location is independent of monopsony power.

This result indicates that MSY's proposition does not hold. If N = 1 and transportation rates are a function of quantity shipped, a change in monopsony power will not change the mix of output and input, but will change the relative transportation costs. Therefore, the relative pulls of the market and the input are affected, and the optimum location is not independent of monopsony power.

4. Conclusions

In this paper, we have incorporated quantity and distance discounts as key variables into the transportation rate functions and examined the theoretical implications of these variables to the effect of monopsony power on the location decision of a monopsonistic firm. MSY's study focuses on the constant transportation rates case. Our work has generalized the study of MSY in the sense that their results are valid only in some special cases.

Assuming that the production function is homogeneous of degree one, we show that the optimum location is independent of monopsony power if the transportation rates are a function of distance only. In this case, MSY's proposition holds. However, if the transportation rates are a function of quantity shipped, then a homogeneous production function of degree one does not ensure that the optimum location is independent of monopsony power. This result shows that in general MSY's proposition fails to apply. The upshot of our analysis is that the present of quantity discount in the transportation rate functions has an extremely important influence on the monopsonistic firm's location decision.

References

Bronfenbrenner, M. (1971) *Income Distribution Theory*, Aldine Atherton: Chicago.

Fair, M. L. and Williams, E.W. (1975) *Economics of Transportation and Logistics*, Business Publication, Chicago.

Lerner, A. P. (1934) "The Concept of Monopoly and the Measurement of Monopoly Power" *Review of Economic Studies* **1**, 157-175.

Mai, C. C. Suwanakul, S. and Yeh, C. N. (1993) "Monopsony and the Production-Location Decision of The Firm" *Regional Science and Urban Economics* **23**, 779-790.

Martinich, J. S. and Hurter, A. P. (1990) "Generalized Comparative Statics for the Production-Location Problem" *Regional Science and Urban Economics* **20**, 275-294.

Miller, S. M. and Jensen, D. M. (1978) "Location and the Theory of Production: A Review, Summary and Critique of Recent Contributions" *Regional Science and Urban Economics* **8**, 117-128.

Moses, L. N. (1958) "Location and Theory of Production" *Quarterly Journal of Economics* **72**, 259-272.

Shieh, Y. N. and Mai, C. C. (1984) "Location and the Theory of Production: Clarifications and Extensions" *Regional Science and Urban Economics* **14**, 199-218.

Stahl, C. (1987) "Theory of Urban Business Location" in *Handbook of Regional and Urban Economics 2* by E.S. Mills, Ed., North-Holland: Amsterdam,750-820.

Yeh, C. N. Mai, C. C. and Shieh, Y. N. (1996) "Location and the Theory of Production under Monopsony" *Papers in Regional Science* **75**, 433-440.

Weber, A. (1929) *Theory of the Location of Industries*, C. Friedrich, trans., University of Chicago Press: Chicago.