NOTES AND COMMENTS

OWNER-OPERATORS, DEMAND FLUCTUATIONS AND THE CHOICE OF TECHNOLOGY

By Peter V. Garrod and Walter Miklius*

The fact that a firm’s choice of technology is dependent on expected fluctuations in output was recognised by Stigler (1939) and Hart (1940) over four decades ago. Recently it has been the subject of a paper by Mills (1981). The basic argument is that when demand fluctuates firms are willing to concede relatively higher costs for levels of output \(q\) near \(q^*\), the point of minimum average cost, in order to obtain relatively lower costs as \(q\) departs from \(q^*\).

Stigler suggested two ways in which a firm can make its production processes more flexible:

The first is based on the divisibility of fixed plant, which will reduce variable cost of suboptimum outputs. The second method is to reduce fixed plant relative to variable services, i.e. to transform fixed into variable costs (p. 316).

The latest available U. S. estimate is that in 1980 there were in the motor carrier industry 170,000 owner-operators, that is, individuals who owned and operated their own trucks (Paxson, 1981).\(^1\) Most of them leased their truck tractors “with driver” to regulated motor carriers and received as their compensation a percentage of revenue earned, instead of being paid on a time or mileage basis. One would expect that the ready availability of owner-operators and their method of compensation would prompt firms in the motor carrier industry to gain more flexibility by using the second method mentioned by Stigler.

This expectation is consistent with the first reason for preference of owner-operators given by the executives interviewed by Maister (1980).\(^2\) These execu-

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\(^1\) However, owner-operators are not peculiar to the U. S. Owner-operators are also important in Australia, Canada, Great Britain, and Sweden. For further discussion see Maister (1980).

\(^2\) Other reasons are that owner-operators are more productive than employees driving equipment owned by the companies, that they are cheaper, that their use allows a rapid expansion of a firm’s capacity, and that they make it possible to avoid union work rules.
tives found that by using owner-operators they were better able to match supply and demand when demand fluctuated unpredictably in the long run, or even when it varied seasonally.

The purpose of this note is to demonstrate that the flexible technology attained by trucking firms through the use of owner-operators is indeed optimal when they face a fluctuating demand for their services. The sequence of presentation is as follows. First comes a summary of the theory of firm behaviour under conditions of fluctuating demand. Next, we derive the conditions under which firms in a competitive industry facing fluctuating demand will prefer a flexible technology. The third section derives similar conditions for firms in a price-regulated industry. The fourth demonstrates that owner-operators do indeed represent a more flexible technology. Finally, we present the available empirical evidence and discuss implications for policy.

BEHAVIOUR OF FIRMS FACING FLUCTUATING DEMANDS

Before examining the implications of relative flexibility for the choice of technology in different environments, we will briefly summarise the expected behaviour of firms in an industry operating under conditions of fluctuating demand with no entry or exit restrictions. Formal proofs of the propositions we present are given in Sheshinski and Dreze (1976). Their assumptions that output is non-storable and thus equal to demand, and that there is zero price elasticity of demand, will be maintained. The assumption of zero price elasticity is equivalent to assuming that the number of firms in the industry is sufficiently large for each firm to be a price taker.

The following notation will be used:

\[ Q = \text{total demand, a random variable with expected value } \bar{Q} \text{ and variance } V; \]
\[ n = \text{number of firms in the industry, all assumed to be identical;} \]
\[ q = \text{the output of a single firm, with expected value } \bar{q} \text{ and variance } v; \]
\[ q^* = \text{the output that minimises average costs. } q^* \text{ will also be referred to as capacity output;} \]
\[ AC = AC(q), \text{ average cost of a single firm, assumed to be U shaped and continuously differentiable;} \]
\[ MC = MC(q) = dqAC/dq, \text{ the marginal cost function, an increasing strictly convex function of } q \text{ with continuous first and second derivatives and } MC > = \frac{dAC}{dq} = q^*. \]

In the above assumed competitive environment, each firm will produce up to the level where price equals marginal cost. At equilibrium, expected profits (defined as \[ E[\Theta] = E[q(MC - AC)] \]) will be zero for all firms.\(^3\) Note that \( \Theta \) is a convex strictly increasing function of \( q \). Then:

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\(^3\) The equilibrium is stable if the number of firms \( n \) increases (decreases) when \( E(\theta) > (\theta) < 0 \). This is normal expected behaviour – positive expected profits will attract entrants, and negative expected profits will cause firms to leave the industry.

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That is, on average there is excess capacity, as the expected output is less than capacity output. This proposition follows from the convexity of $\Theta$ and the condition that profit is zero. Also:

$$MC(\overline{q}) < E(MC) < MC(q^*) = AC(q^*) < E(AC)$$

The first inequality (on the left) follows from the convexity of $MC$. The second is proved by Sheshinsky and Dreze (1976) by contradiction. The third follows immediately from $AC(q) > AC(q^*)$ for all $q \neq q^*$. And

$$E(qMC)/\overline{q} = E(qAC)/\overline{q} > AC(\overline{q}) > AC(q^*).$$

The equality follows from the condition of zero profit. The convexity of $MC$ implies that $qAC$, or total costs, is convex. Therefore $E(qAC)/\overline{q} > AC(\overline{q})$.

In an environment where prices are regulated rather than determined by marginal costs, the conditions characterising the equilibrium change. Assume that price is regulated and set equal to expected marginal costs, or $P^r = E(MC)$. Then in equilibrium

$$n^r < n^c$$

where the superscripts $r$ and $c$ refer to regulated and competitive industries.

This statement follows from the fact that $q$ and $MC$ are positively correlated; thus $E(MC\overline{q}) < E(qMC)$ or expected revenues in the price-regulated industry are less than in the competitive industry. This directly implies that

$$\overline{q}^r > \overline{q}^c$$

or that the average output per firm is greater under regulation.\(^4\) Also

$$P^r > MC(q^*)$$

must be true for $E(\Theta) = 0$. Sheshinsky and Dreze (1976) also show that, for a constant number of firms, expected profits increase with increases of either $V$ or $Q$.

**FLUCTUATING DEMAND AND COMPETITION**

We now present some results comparing an industry composed of flexible firms, denoted by a subscript $f$, with a relatively less flexible industry, denoted by a subscript $s$, both operating in identical environments, with identical capacity outputs ($q^*$) and composed of the same number of firms. Flexibility is defined as the reciprocal of the slope of the marginal cost curve ($MC^{-1}$), evaluated at the

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\(^4\) Note that this does not imply that capacity is greater. Capacity output has been fixed by assumption at $q^*$. It does imply that expected excess capacity will be less under regulation.
point of minimum average costs. That is, flexibility is greatest when marginal costs rise gently and average costs are flat near their minimum point. Stigler (1939) does not define flexibility rigorously, but Marschak and Nelson (1962) and later Tisdell (1963) argue that flexibility varies inversely with the curvature of total costs, and that Stigler's notion of flexibility is accurately captured in the above definition.

First, by the definition of flexibility

\[ MC_f' < MC_s' \]

For the basis of comparison assume that

\[ AC(q^*)_f = AC(q^*)_s. \]

Then

\[ AC_f < AC_s \text{ for all } q \neq q^* \]

and

\[ MC_f' < = > MC_s' \text{ as } q = < q^*. \]

Both statements follow directly from the definition of flexibility and the shape of average and marginal cost curves.

In a competitive industry profits are defined as \( \Theta = q(MC - AC) \). These two statements then directly imply that \( \Theta_f > \Theta_s \) whenever profits are positive, and the converse whenever profits are negative. That is:

\[ \Theta_f < = > \Theta_s \text{ as } q = < q^* \]

This relationship is illustrated in Figure 1. For any price which is equal to marginal cost, the profits based on the flexible cost relationships, equal to \( (P - P^*)q \) or unit profits multiplied by \( q \), will exceed those based on the less flexible cost curves.

Thus, under the assumed conditions, the industry would always choose the more flexible technology. Even if \( AC(q^*)_f > AC(q^*)_s \), the flexible technology will be the optimal choice as long as \( E(\Theta)_f > E(\Theta)_s \).

An expression for the maximum difference in minimum average costs under which the flexible technology remains the optimal choice can be derived by taking a Taylor's expansion of \( E(\Theta) \) and dropping all expressions of order greater than 2. After some manipulation this yields

\[ AC_f - AC_s = (MC_f' - MC_s')(q^*d + B) + (MC_s'' - MC_f'')B \]

where \( d = \bar{q} - q^* \) and \( B = (v + d^2)/2 \) and all expressions are evaluated at \( q^* \).

Thus, the flatter the marginal cost curve of the flexible technology and the smaller the rate of change in the slope of the marginal cost curve of the flexible technology relative to the less flexible technology, the greater the difference in minimum average costs can be before the less flexible technology becomes optimal. Also (as \( B \) is positively related to the variance of demand) the larger the expected fluctuations in demand, the greater the difference in minimum average costs can be before flexible technology ceases to be the more profitable.

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FLUCTUATING DEMAND AND REGULATION

In a price-regulated industry the same conclusion holds, though the expression for the maximum permissible difference in minimum average costs takes a different form. The condition of zero expected profit requires that

$$P = \frac{E(qAC)}{\bar{q}}$$

must hold at equilibrium. Given the assumptions of equal $q^*$ and $AC(q^*)$ for both technologies, the flexible one will always be the more profitable. This is illustrated in Figure 2. Profits are defined in Figure 1, and for any price the flexible technology is the more profitable.

The maximum difference in the minimum average costs that maintains the optimality of the flexible technology can be approximated by taking a Taylor's expansion of $E(qAC)$ around $q^*$ and ignoring all terms of order greater than 2. After some manipulation, obtain

$$E(qAC)/q = MC(q^*) + MC(q^*)'A,$$

where

$$A = \frac{1 + (\bar{q} - q^*)^2}{2\bar{q}}.$$

Using Marschak and Nelson's definition of flexibility, $F = 1/MC(q^*)'$, the condition for the more flexible technology to be optimal becomes

$$[MC(q^*)_f - MC(q^*)_s] \leq [F_s^{-1} - F_f^{-1}] A.$$
or, as \( MC(q^*) = AC(q^*) \):

\[
\left[ AC(q^*)_f - AC(q^*)_s \right] \leq \left[ F_f - F_s \right] A/F_s F_f.
\]

Thus, the larger the difference in flexibility, the greater can be the difference in minimum average costs.\(^5\) Also, as \( A \) is positively related to the variance of demand, the larger the (expected) fluctuations in demand, the greater the difference in minimum average costs or the smaller the difference in flexibility must be before the less flexible technology is preferred.

**OWNER-OPERATORS AND THE FLEXIBLE TECHNOLOGY**

Assume that the cost functions of trucking firms are additively separable and can be broken down into three components: a fixed cost component \( F \), a variable cost component relating to overhead costs \( A \), and a variable cost component related to owning and operating the trucks \( T \). Further assume that both \( A \) and \( T \) for capacity output equal to \( q^* \) are strictly increasing functions of \( q \) with positive first and second derivatives, and are identical for all firms. The cost function for a firm that owns its own trucks, denoted by subscript \( o \), would then be

\[
C_o = F + A(q) + T(q)
\]

\(^5\) To show this, define the difference in flexibility as \( D \); then the term on the right-hand-side becomes \( DA/[\{(F_s + D)F_s\}] \). The first derivative of this expression with respect to \( D \) is positive.

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with

\[ MC_o = A' + T' \]

and

\[ MC'_o = A'' + T''. \]

For a price-taking firm that hires owner-operators, denoted by subscript \( h \), the cost equation is

\[ C_h = F + A(q) + rPq \]

with

\[ MC_h = A' + rP \]

and

\[ MC'_h = A'' \]

where \( r \) is the proportion of revenues going to the owner-operators. Clearly

\[ MC'_h < MC'_o \] or \( F_h > F_o \]

and firms employing owner-operators are the more flexible.

As demand fluctuates over time, \( P \) would be expected to vary in the same direction as total demand. This relationship between total demand and price, however, does not affect the above derivation for the firm that hires owner-operators as long as the firm is still a price-taker. That is, even if \( P \) varies in the same direction as total demand, causing the \( MC \) function of the firm to rise and fall with demand, the function will have the same form as long as no action taken by the individual firm can affect \( P \).

EMPIRICAL EVIDENCE

These conclusions lead one to expect that the larger the seasonal or cyclical fluctuations in demand facing the carriers, the more likely they are to use owner-operators. The available evidence is, by and large, consistent with this expectation. The carriers of household goods have a very pronounced seasonal peak during the summer months. In fact, for some carriers this peak accounts for some four-fifths of all household moves. One would therefore expect the carriers of household goods to be heavy users of own-operator services. And indeed they are. In 1980 more than three-quarters of all power units used by these carriers were "rented with drivers" (Table 1).

On the other extreme are the general freight carriers. There is not much seasonal variation in their traffic, and they are much less affected by economic downturns than carriers of special commodities. In fact, the extent to which a particular general freight carrier is affected by cyclical fluctuations depends on whether that carrier transports truckload (TL) or less-than-truckload (LTL)
traffic, since during recessions LTL shipments actually tend to increase, while TL shipments tend to fall. (For further discussion see ICC (1981).)

We should therefore expect to find that only carriers of general freight specialising in TL shipments are users of owner-operator services. Since the great majority of general freight carriers derive most of their revenues from LTL shipments, as a group these carriers should not be heavy users of owner-operator services. Again, this is indeed true. In 1980 less than 10 per cent of power units used by general freight carriers were “rented with drivers” (Table 1).

Other special commodity groups appear to fall in between the carriers of household goods and of general freight. The available evidence, however, is fragmentary and somewhat mixed. Table 2 shows the percentage decrease in traffic (over the same quarter of the preceding year) for various special commodity carriers during the last three recessions. The corresponding percentage change in the Index of Industrial Production is included for reference. There appears to be little consistency in the pattern or in the degree of severity across the special commodity carriers or between recessions. Nor do the decreases in traffic coincide with falls in the Index of Industrial Production. Nevertheless, these data suggest that carriers of building materials and motor vehicles are more sensitive to cyclical

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TABLE 2
Decline in Tonnage during the 1967, 1970 and 1975 Recessions for Carriers of Special Commodities

<table>
<thead>
<tr>
<th>Type of Carrier</th>
<th>1967</th>
<th></th>
<th>1970</th>
<th></th>
<th>1975</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>qtr.</td>
<td>% decline</td>
<td>qtr.</td>
<td>% decline</td>
<td>qtr.</td>
<td>% decline</td>
</tr>
<tr>
<td>Agriculture</td>
<td>3</td>
<td>17.1</td>
<td>1</td>
<td>3.6</td>
<td>2</td>
<td>7.4</td>
</tr>
<tr>
<td>Building materials</td>
<td>2</td>
<td>9.0</td>
<td>3</td>
<td>6.1</td>
<td>3</td>
<td>14.3</td>
</tr>
<tr>
<td>Heavy machinery</td>
<td>2</td>
<td>2.4</td>
<td>4</td>
<td>5.7</td>
<td>4</td>
<td>10.5</td>
</tr>
<tr>
<td>Liquid petroleum</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>2.3</td>
<td>2</td>
<td>16.8</td>
</tr>
<tr>
<td>Motor vehicles</td>
<td>4</td>
<td>11.0</td>
<td>4</td>
<td>27.7</td>
<td>1</td>
<td>42.0</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>9.0</td>
<td>4</td>
<td>4.9</td>
<td>2</td>
<td>18.5</td>
</tr>
<tr>
<td>Index of Industrial Production</td>
<td>–</td>
<td>–</td>
<td>4</td>
<td>5.3</td>
<td>2</td>
<td>12.8</td>
</tr>
</tbody>
</table>

a First quarter of 1971
Source: ICC (1981)

falls than other carriers. However, only carriers of building materials were heavy users of owner-operator services, renting over 40 per cent of their power units with drivers (Table 1).

In contrast with our expectation based on cyclical sensitivity, the carriers of motor vehicles do not rely on power units rented with drivers. One may speculate that other factors were more important. Furthermore, no data on cyclical sensitivity are available for carriers of refrigerated commodities, though it is known that they rely heavily on owner-operators to supply more than half of their power units.

REFERENCES


