Menu costs, firm size and price rigidity

Robert A. Buckle\textsuperscript{a,\*}, John A. Carlson\textsuperscript{b}

\textsuperscript{a}School of Economics and Finance, Victoria University of Wellington, P.O. Box 600, Wellington, New Zealand
\textsuperscript{b}Krannert School of Management, Purdue University, West Lafayette, USA

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Abstract

If menu costs have a non-negligible lump-sum component and with larger firms having greater benefits from price adjustments, then larger firms will change price more frequently than smaller firms. Data from New Zealand firms support this hypothesis. Price duration decreases as firm size increases. Ordered probit analysis indicates the effect comes primarily from larger firms being more likely than smaller firms to raise price in response to a demand or cost increases. © 2000 Elsevier Science S.A. All rights reserved.

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JEL classification: E3; D4

1. Introduction

‘Menu costs’ of price adjustment have become a popular explanation for price stickiness in markets characterised by monopolistic competition (See reviews by Andersen, 1994; Ball and Mankiw, 1994; Benassi et al., 1994, ch. 7). Menu costs include administrative, technical and informational costs of deciding on and implementing a price change. A significant proportion of these costs is likely to be lump-sum and independent of firm size. For example, an important cost of price adjustment is the time and attention required by managers to gather the relevant information to make and implement pricing decisions (Levy et al., 1997). Similarly, although the total cost of changing price lists, tags and catalogues and advertising price changes may vary with firm size (for instance, firms with a large volume of output may need to distribute new price catalogues to a larger number of distribution outlets), there will nevertheless be lump-sum set-up costs which are likely to be similar across firms irrespective of their size.
If menu costs involve a common lump-sum component, the cost of price adjustment per unit of output will fall systematically as firm size increases. It follows, therefore, that in the presence of lump-sum menu costs and common shocks to desired price, other things equal, small firms will tend to exhibit greater price rigidity than large firms.

We present a simple expression that captures the relationship between firm size and the benefit of a price change following a shock to desired price. Data from a survey of New Zealand firms is then used to measure price rigidity: (i) by an estimate of price duration, defined as the average length of time between successive price changes and (ii) by price responsiveness of firms to cost and demand changes.

2. Hypotheses about the effects of firm size on price rigidity

Consider a simplified version of an optimal Ss rule for a price setting monopolist specified by Blanchard and Fischer (1989, pp. 402–405). Assume the following linear demand and cost functions:

\[ Y = \alpha - \beta P + \mu; \quad \alpha, \beta > 0 \]

\[ C = (\delta + \eta)Y; \quad \delta > 0 \]

where \( Y \) = output, \( P \) = price, \( C \) = costs of producing output and \( \mu \) and \( \eta \) are shifts in demand and costs, respectively. There are two differences from the specification in Blanchard and Fischer. The first is that we have dropped their quadratic term in the cost function. The second is the introduction of cost shifts.

Suppose price has been set to maximize profits when \( \mu = 0 \) and \( \eta = 0 \). As \( \mu \) and \( \eta \) change over time, the firm could increase profits by changing its price but may not do so when there are menu costs of making a price change. When \( \mu \) and/or \( \eta \) are non-zero, the difference between profits with an optimal price and profits with no change in price can be shown to be:

\[ B(\mu, \eta) = \frac{\mu^2}{4\beta} + \frac{\beta\eta^2}{4} + \frac{\mu\eta}{2} = (\mu + \beta\eta)^2/4\beta \]

Call this benefit from changing price the opportunity cost of not changing price. Suppose that the firm will change price whenever this opportunity cost exceeds a critical level that represents the cost of making a price change. At that point, price is reset optimally, the \( \alpha \) and \( \delta \) parameters are redefined to include the \( \mu \) and \( \eta \) changes that have occurred since the prior price change, and the process is repeated.

We have assumed that larger firms have a larger demand. More explicitly, in this model a larger firm has larger values of both \( \beta \) and the standard deviation of \( \mu \). However, any upward shift in costs will tend to be the same across firms of different size. As a result, examination of Eq. (3) reveals that \( B(\mu, \eta) \), the opportunity cost of not changing price, rises in direct proportion to firm size.

If the cost of changing price has a non-negligible lump-sum component or rises less than proportionately to the increase in the size of the firm, then smaller firms will tend to change price less frequently than larger firms. Consider, for example, a distribution of cost changes. Larger firms, with larger values for \( \beta \), will have a more dispersed distribution of \( B(\mu, \eta) \). As a result a higher proportion
of larger firms with cost increases will decide to raise price and a higher proportion with cost decreases will decide to lower price compared to smaller firms. A similar prediction holds for demand changes if larger firms tend to have a more dispersed distribution of demand shifts.

If, as suggested by the foregoing argument, larger firms change prices more frequently than smaller firms do, then we predict that a measure of price duration, the average time between price changes, will be longer for smaller firms.

3. Micro firm data

Information about firm price, cost and demand changes and firm size was obtained from the New Zealand Institute of Economic Research’s Quarterly Survey of Business Opinion. This survey involves the distribution to business executives of a standard questionnaire that identifies the firm, its principal activity, location, size, and a series of questions asking about the firm’s operating environment. It also contains a standard question asking executives to report their perceptions of the actual change during the immediate past 3 months for several activity variables including average selling prices, average costs, and new orders. Firms do not indicate the magnitude of change, only the direction of change, whether up, same or down.

Firms were allocated to a size category according to their response to the following question: How many employees are covered by this return? There are six size categories: (1) Employees ≤ 20; (2) 20 < Employees ≤ 50; (3) 50 < Employees ≤ 100; (4) 100 < Employees ≤ 200; (5) 200 < Employees ≤ 500; (6) 500 < Employees.

4. Tests of relative price rigidity

4.1. Duration of prices

The following procedure was used to obtain statistics for price duration. Let \( p_u \) = percent of firms reporting price increases in the last \( n \) months and \( p_d \) = percent of firms reporting price decreases in the last \( n \) months. An average time \( T \) in months between price changes is then given by the following:

\[
T = \frac{n}{(p_u + p_d)}
\]

For example, if in a quarterly survey 75% of the firms report they did not make a price change in the last 3 months and 25% did, then a representative firm will go \( 3 / 0.25 = 12 \) months before changing price. There are potential biases in this measure. On the one hand, if firms tend to change prices on only some items during the quarter but their average prices are up or down, then \( (p_u + p_d) \) overestimates the extent of price changing activity and \( T \) is biased downward. On the other hand, if firms change prices more frequently than once a quarter, then \( T \) overestimates the average duration between price changes.

Table 1 shows price duration estimates for New Zealand manufacturing and building firms by firm size using this procedure. From Table 1 it is clear that the length of time firms hold prices constant does in fact vary by firm size. The smallest firms in our sample changed prices on average every 8.1
Table 1
Duration of prices by firm size (quarterly surveys: 1984:3–1996:1)*

<table>
<thead>
<tr>
<th>Firm size:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>All firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price duration (months)</td>
<td>8.1</td>
<td>7.6</td>
<td>6.6</td>
<td>6.4</td>
<td>6.2</td>
<td>5.1</td>
<td>6.7 (1.03)</td>
</tr>
</tbody>
</table>

* Standard error in parentheses.

months during our 11.5-year sample period. This is more than 50% longer than the average 5.1 months duration of prices for the largest firms. There is also a perfect rank-order correlation between firm size and the average frequency of price changes. These results strongly support our hypothesis that large firms change price more frequently than small firms.

4.2. Price responsiveness to cost and demand changes

We next look more specifically at the effect of firm size on price responsiveness to cost and demand changes. To do that, we use ordered probit regressions to estimate the influence of changes in costs and demand on the probability of a change in price separately for small firms (categories 1 and 2) and large firms (categories 5 and 6).

The idea of an ordered probit analysis is to assign a value \( v \) to each price change observation. According to expression (3) the probability of a price change will be influenced by changes in costs and changes in demand. In our particular application, for firm \( j \) at time \( t \), let

\[
v_{jt} = \gamma_1 c_{jt} + \gamma_2 d_{jt}\]

(5)

where \( c \) = change in costs (\( c = 1 \) if costs = ‘Up’, \( c = 0 \) if costs = ‘Same’, \( c = −1 \) if costs = ‘Down’) and where \( d \) = change in demand (\( d = 1 \) if demand = ‘Up’, \( d = 0 \) if demand = ‘Same’, \( d = −1 \) if demand = ‘Down’) experienced by firm \( j \) in quarter \( t \). Let \( u \) be a standard normal variable (with zero mean and variance of one) and define three price change probabilities:

\[
\Pr[\text{price} = \text{down} | c, d] = \Pr[u < k_1] = \Pr[u < k_1 - v]\]

(6)

\[
\Pr[\text{price} = \text{same} | c, d] = \Pr[k_1 < u < k_2] = \Pr[k_1 - v < u < k_2 - v]\]

(7)

\[
\Pr[\text{price} = \text{up} | c, d] = \Pr[k_2 < u + v] = \Pr[k_2 - v < u]\]

(8)

An ordered probit regression procedure estimates the coefficients \( \gamma_1 \) and \( \gamma_2 \) and two ‘cut-point’ parameters \( k_1 \) and \( k_2 \) that maximize the likelihood of observing the actual sample of reported price changes (see Greene, 1993; and Stata Corporation, 1995). Table 2 reports the results of ordered probit estimates. The coefficients on cost and demand changes are highly significant for both small and large firms.

To assess the relative responsiveness of large and small firms to cost and demand changes, we need to convert these estimates into probabilities of price changes in response to specific cost and demand changes. For example, for small firms that report a cost increase (\( c = 1 \)) and no demand change (\( d = 0 \)), the probability of a price increase is given by the \( \Pr[0.78 + u > 1.05] = \Pr[u > 0.27] = 0.39 \) where the
Table 2
Ordered probit estimates of influences of cost and demand changes on price changes (quarterly observations: 1984:3 – 1996:1) $v_{jt} = \gamma_1 c_{jt} + \gamma_2 d_{jt}$,*

<table>
<thead>
<tr>
<th></th>
<th>Small firms</th>
<th>Large firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. observations</td>
<td>2549</td>
<td>2646</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>0.78 (19.10)*</td>
<td>0.59 (18.14)*</td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>0.37 (12.24)*</td>
<td>0.20 (7.33)*</td>
</tr>
<tr>
<td>$k_1$</td>
<td>-0.95</td>
<td>-0.85</td>
</tr>
<tr>
<td>$k_2$</td>
<td>1.05</td>
<td>0.60</td>
</tr>
</tbody>
</table>

* z ratios are in parentheses; *denotes significant at 1% level.

Table 3
Conditional probabilities of price changes $Pr[price = up | c,d] = Pr[k_2 - v < u]$ $Pr[price = down | c,d] = Pr[u < k_1 - v]^*$

<table>
<thead>
<tr>
<th></th>
<th>Small firms</th>
<th>Large firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Pr[p = up</td>
<td>c = up, d = same]$</td>
<td>0.39</td>
</tr>
<tr>
<td>$Pr[p = up</td>
<td>c = same, d = up]$</td>
<td>0.25</td>
</tr>
<tr>
<td>$Pr[p = down</td>
<td>c = down, d = same]$</td>
<td>0.43</td>
</tr>
<tr>
<td>$Pr[p = down</td>
<td>c = same, d = down]$</td>
<td>0.28</td>
</tr>
</tbody>
</table>

$^*$ $v_{jt} = \gamma_1 c_{jt} + \gamma_2 d_{jt}$. Probabilities are based on estimates of the $\gamma$ and $k$ coefficients reported in Table 2.

last equality comes from a table of standard normal variables. These probabilities for small and large firms are shown in Table 3.

In response to a cost increase, large firms have a 50% probability of raising price, whereas small firms have only a 39% probability. In the case of a demand increase, large firms have a 35% probability of raising price and small firms 25%. Thus, as predicted, large firms are more likely to increase price in response to a cost increase or to a demand increase than small firms.

When there are cost or demand decreases, there is not much difference in the probabilities that large firms will lower price than small firms. In fact, small firms appear slightly more likely to decrease price in response to a cost decrease or to a demand decrease than large firms. We had not expected that result. The shorter price duration for larger firms arises primarily because larger firms are quicker to respond to cost and demand increases than are smaller firms.

References

Stata Corporation, 1995, Stata Statistical Software: Release 4.0, College Station, TX, USA.