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Inflation and Costly Price Adjustment: A Study of Canadian Newspaper Prices

The paper studies the effect of inflation on price behaviour using price data from Canadian daily newspapers. We test the Sheshinski and Weiss (1977) monopoly price adjustment model on a sample of monopolistic as well as oligopolistic newspapers, in contrast to earlier studies that used data from oligopolistic or monopolistically competitive markets. The results depend crucially on the assumptions about how often the firm collects information and revises its optimal pricing policy. With infrequent policy revisions, the results for monopoly newspapers support the model. The results for oligopoly newspapers are similar.

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SINCE KEYNES (1936), a central issue in macroeconomics has been the rigidity of nominal prices. The development of microfoundations of macroeconomics in the last 20 years has, if anything, increased the importance of this issue. In fact, it has become so important that it has led two prominent economists to write "A Sticky Price Manifesto" (Ball and Mankiw 1994). This reminds us of another famous manifesto written by two prominent economists (Marx and Engels 1848). The recent experience of communism has underscored the fact that manifestos rise or fall on the basis of empirical evidence. In this paper we analyse some evidence in favour of sticky prices.

An important basis for sticky prices is the fact that, even under rapid inflation, nominal prices are changed infrequently. One explanation is that nominal price adjustment is costly. This has led to the costly price adjustment approach, started

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by Barro (1972) and developed by Sheshinski and Weiss (1977, 1983) and others. The costs of changing the nominal price can be divided into three types. The first is the literal or menu cost (printing labels, informing salesmen and customers, etc). The second are the costs of the decision process: collecting information, analysing changes in the frictionless optimal real price and deciding on the new nominal price. Lastly, there are costs resulting from unfavourable reaction of competitors and/or customers to price changes.[1]

The basic microeconomic model (Sheshinski and Weiss 1977) implies that the optimal pricing policy is of the (s, S) type. The firm allows the real price to vary between two price bounds. Whenever inflation erodes the real price to the lower bound, s, the nominal price is then raised so that the new real price is equal to the upper bound, S. Higher inflation implies a higher value of S, a lower value of s and larger price changes; the effect on the frequency of adjustment is ambiguous.[2]

The problem with the literature is that existing empirical studies, while providing ample evidence on the rigidity of individual nominal prices, sometimes reject the basic microeconomic model. In Lach and Tsiddon (1992) and in Kashyap (1995), for some goods, the size of adjustment falls when the inflation rate increases while in Cecchetti (1986) and Dahlby (1992) inflation does not appear to affect the price bounds.

These rejections are, perhaps, not surprising as the assumptions of the basic model are difficult to meet in empirical work. Sheshinski and Weiss (1977) assume that the firm is an unregulated monopoly that produces a single, perishable good, the rate of inflation is constant, the cost of price adjustment is lump-sum (i.e., independent of the size or frequency of price changes) and demand and real costs are constant. Testing requires specialized data (prices of individual goods in individual stores or firms) which are difficult to obtain and so available data violate many, if not most, of these assumptions. Since optimal pricing policy may be quite different in other environments[3] these rejections may not be robust and have been largely ignored.

Further progress of the empirical literature requires, therefore, careful evaluation of the assumptions of the model. The contribution of this paper is twofold. First, our data allow us to distinguish between monopoly and oligopoly firms. We provide the first evidence on price behaviour of unregulated monopolies.[4] The distinction is crucial to the menu cost models; optimal oligopoly pricing with menu costs is a difficult problem and few theoretical results are available. A notable exception is

1. Levy et al. (1997) and Dutta et al. (1999) provide detailed information on the size of the costs in a grocery and in a pharmacy chain, respectively. Zbaracki et al. (2004) analyze managerial- and customer-type costs in an industrial firm. Rotemberg (2002) develops a model in which consumers react negatively to select price changes and provides some evidence.

2. A sufficient condition for the frequency of price changes to increase with inflation is that the profit function be strictly concave in the log of the real price (Sheshinski and Weiss (1977) call it the monotonicity condition).

3. For example, if the product is storable, the frequency and size of price changes is stochastic even in a stationary environment (Bénabou 1988); if the costs of adjustment depend on the frequency or/and size of changes the effect of inflation on both is ambiguous (Konieczny 1993).

4. Sheshinski, Tishler, and Weiss (1981) analyse regulated monopolies.

Slade (1999) who analyses an oligopolistic market and finds that strategic consideration exacerbates price rigidity: price changes are larger and more frequent than under monopolistic competition.

Second, we ask how to address the fact that, in actual data, the inflation rate, demand, and real costs all vary over time. We test the model under alternative approaches to the formulation of optimal policy in a nonstationary environment. We call them the *continuous* pricing policy and the *discrete* pricing policy. Under the continuous policy the firm constantly monitors market conditions and revises the optimal price bounds accordingly. Under the discrete policy, information is collected and the price bounds revised only at the time of adjustment. Existing empirical studies implicitly assume a continuous approach. There are, however, reasons to believe that the discrete approach may be preferred. Zbaracki et al. (2004) find that the costs of price changes in terms of management time are almost an order of magnitude higher than the physical costs and that the "hard" customer costs (communicating and negotiating new prices) are 30 times higher while Levy et al. (2002) find that price changes are less frequent at the end of the year when high volume of sales makes management time expensive. Mankiw and Reis (2002) develop a model in which getting informed, rather than changing prices, is costly. A firm can reduce these costs by following the discrete approach.[5]

Newspaper price data have some additional desired features. The good is clearly perishable. A newspaper is one of the best examples of a firm that produces a single product. The pricing decision is crucial for a newspaper since the proportion of revenue derived from sales is substantial. Of course, the newspaper can affect its revenue by trying to adjust its advertising rates or quality (e.g., size). Advertising, however, is crucially dependent on circulation and so on the price of the paper. In single-newspaper cities the paper has monopoly power over a large portion of its advertising. The prices are actual transaction prices since discounts are rare. Temporary discounts for weekly delivery do exist but they are targeted at specific customers. Finally, the physical cost of price adjustment is, essentially, zero while management cost may be substantial, given the crucial role of the newspaper price.

Our results show that it is the way policy is formulated in a nonstationary environment that is crucial; the differences between the two types of firms do not appear to be important. For the discrete approach, the results strongly support the model in the case of monopolies; for oligopoly papers the results are weaker but consistent with the model. However, under the continuous case, for both types of firms the results are often of wrong sign and are not significant.

The fact that there is little difference between the behaviour of monopolies and oligopolies provides a justification for the use of the menu cost model in macroeconomics. At present, theoretical results are available only for monopoly and monopolistically competitive markets. However, many markets are oligopolistic; our results suggest that the basic model may be an adequate description of price behaviour in such markets as well.

5. Carroll (2003) develops and tests a model in which individuals adopt a cost-saving approach to collecting information.

The plan of the paper is as follows. The data are described in Section 1, which also contains preliminary analysis. In Section 2 we discuss the continuous and discrete pricing policies. Some data issues are discussed in Section 3. The empirical approach is described, and results discussed, in Section 4. The last section concludes.

1. DESCRIPTION OF THE DATA AND PRELIMINARY ANALYSIS

The data consist of prices of daily newspapers in Canada over the period 1965–90, collected by the Canadian Daily Newspaper Publishers Association (CDNPA) and circulation data from The Audit Bureau of Circulation.[6] The newspaper industry was not regulated during this period (except for economy-wide price controls in 1975–78); its product is clearly perishable. Newspapers provided CDNPA with data on several prices: single copy, wholesale (newsstand and coin-box), home delivery (carrier and wholesale), motor route as well as mail subscription for 3, 6, and 12 months. Out of the around 100 daily newspapers in Canada we selected 64 papers for which we have 38 observations each, starting in December 1965 and ending in April 1990. The list of papers is in Appendix A. The information was collected at irregular intervals: the shortest period between observations was 2 months (4.80–6.80 and 2.89–4.89), the longest was 18 months (1.73–7.74).

The data allow us to make the crucial distinction between market structures: 51 of the 64 newspapers are from one-newspaper cities. Given the geographical environment, these 51 newspapers are monopolies. The remaining 13 newspapers have competitors in the same city.[7] The distinction between monopolies and oligopolies in our sample is clear-cut. Obviously, if you want to know what is happening in the Yukon, only the Whitehorse Star will do. During the period studied there was only one national newspaper in Canada: the Globe and Mail. It was not a close substitute for local papers outside of Toronto. The only single-paper markets where there is a possibility that the local paper faces competition from another newspaper are cities around Toronto. However, in the industry view, even these newspapers are monopolies: “But he [Paul Godfrey, president of the Sun newspaper chain] is quick to boast that Sun Media now controls the top three Ontario newspapers with monopoly markets: the Hamilton Spectator, London Free Press and The [Kitchener-Waterloo] Record.” (The Record, October 29, 1998, p. F3).

Data for wholesale coin-box and for motor delivery prices are limited, and mail rates for different periods are almost always changed together. Therefore, for each newspaper, we initially consider five prices: single copy (weekday), dealer (weekday), weekly carrier, wholesale carrier, and yearly subscription. The dealer price is the wholesale price paid by stores which sell single copies; the wholesale carrier

6. Out of about 100 newspapers, we excluded papers for which data were incomplete.

7. In some cities all newspapers are published by the same company (e.g., Vancouver); these are treated as a monopoly.

TABLE 1
COINCIDENCE OF PRICE CHANGES

	Single Copy	Dealer	Weekly Carrier	Wholesale Carrier	One-Year Mail Rate
Single copy	1.00	0.87	0.83	0.74	0.67
Dealer	0.83	1.00	0.81	0.82	0.67
Weekly carrier	0.43	0.44	1.00	0.84	0.70
Wholesale carrier	0.43	0.49	0.93	1.00	0.70
One-year mail rate	0.35	0.37	0.71	0.64	1.00

price is paid by the suppliers of papers to the door-to-door distributors. Table 1 shows the coincidence of price changes across the five prices: e.g., the dealer price is changed in 87% of cases when the single copy price is changed. Not surprisingly, each wholesale price usually moves together with the corresponding retail price. The yearly subscription price tends to move together with the carrier price.

In most cases below we analyse the weekly carrier price. For most newspapers more than a half of the sales are to weekly subscribers. The dealer and the wholesale carrier prices may be affected by discounts.[8] The single copy (and dealer) price changes are, to a large extent, dominated by the convention that the price charged be a multiple of five cents. The mail rate is the least important as few newspapers are sold by mail subscription.

The pricing decision is crucial for newspapers since the proportion of revenue derived from sales is substantial. Of course, a newspaper can affect its revenue by trying to adjust its advertising rates or quality (e.g., size). Advertising, however, is crucially dependent on circulation and so on the price of the paper. In single-newspaper cities the paper has monopoly power over a large portion of its advertising. The prices are actual transaction prices, as discounts are rare. Temporary discounts for weekly delivery do exist, but they are targeted to specific customers (such as new subscribers or university students). Finally, the physical cost of price adjustment is, essentially, zero while management cost may be substantial, given the crucial role of the newspaper price. Our data do not allow us to assess potential changes in newspaper quality and so we assume it did not change.[9]

To get an idea about the behaviour of prices we begin the analysis by taking a cursory look at the relationship between inflation and the size and frequency of price changes. The period covered by the study can be divided into high (1973–82) and low (1967–72 and 1983–90) inflation periods. The average inflation for the 1967–90 period was 6.5%. For each year in the period 1973–82 the inflation rate exceeded 6.5% (with an average of 9.6%) and for each year in the periods

8. One indication of discounts is that there are no price decreases for the weekly carrier price, 16 for the wholesale carrier price; none for the single copy price and five for the dealer price.

9. A few newspapers did change formats during the sample period, e.g. the Vancouver Province, which became a tabloid in 1982, and the Toronto Telegram, which became a tabloid in 1971 under the name Toronto Sun.

TABLE 2

Difference between Mean Values for High- and Low-Inflation Periods

Price	Average Time between Price Changes (a)	Average Price Change (%) (b)	Average Elapsed Inflation (%) (c)
Single copy	4.53^{+} (0.07)	6.96*(0.00)	16.63*(0.00)
Weekly carrier	0.30 (0.78)	2.15*(0.00)	9.00*(0.00)
Carrier	−0.75 (0.50)	1.92*(0.03)	8.86*(0.00)
Dealer	3.36 (0.16)	8.87*(0.00)	15.91*(0.00)
Mail rate	−0.54 (0.64)	−6.08*(0.00)	7.89*(0.00)

Notes: 1. All cells give the value for the high inflation period minus the value for the low inflation period. 2. Probability values are in brackets. Statistical significance is denoted by * at the 5% level and + at the 10% level, based on a two-tailed *t*-test.

1967–72 and 1983–90 the inflation rate was below 6.5% (with an average of 4.3%). Table 2 presents results from tests for the difference between the mean values of (a) the time between price changes, (b) the size of price changes, and (c) elapsed inflation since the previous price change. The last variable indicates the extent to which the real price has fallen prior to adjustment; it differs from the size of price changes, as inflation is not constant. This information is important for the two approaches to the optimal pricing policy, discussed in detail below.

In the high inflation period price changes are bigger (with the exception of the mail rate), and newspapers allow their prices to decrease more, than in the low inflation period; the differences are highly significant. Both findings are consistent with the model. On the other hand, the time between price changes is not significantly different between high and low inflation periods.[10]

In order to uncover the differences in the response of monopolies and oligopolies to inflation, Table 3 separates the information for the two types of firms. For both types of firms the real price is allowed to decline more before adjustment in the high inflation period (1973–82) than in the low inflation periods (see Columns (c)). The size of price changes is higher in the high-inflation period for all prices except the mail rate for monopolies, and for all prices except the mail rate and the single copy price for oligopolies. The response pattern of the frequency of price changes, however, differs between the two types of firms. For monopolies, the time between price changes is shorter in the high inflation period for the carrier and weekly carrier prices. In contrast, for oligopolies it is shorter for the single copy price and the mail rate (see Columns (a)).

To summarize, the pattern of price adjustment appears to be broadly consistent with the basic model: in the high inflation period price changes are bigger, the real price is allowed to decline more between adjustments while the effect on the frequency of price changes is ambiguous. Market structure appears to be more important for the frequency than for the size of price changes.

10. The single copy price is an exception. This may be due to the fact that the single copy price is almost always a multiple of five cents.

TABLE 3

PRICE CHANGE DATA FOR MONOPOLIES AND OLIGOPOLIES, HIGH AND LOW INFLATION PERIODS

		Average Time between Price Changes (Months) (a)			Average Price Change (%) (b)			Average Elapsed Inflation (%) (c)		
Price	Period	All	Mon.	Oli.	All	Mon.	Oli.	All	Mon.	Oli.
Single copy	1967–72, 1983–90	38.2	37.0	45.9	22.7	21.6	29.9	18.1	16.7	27.0
	1973–82	42.7	45.5	39.5	29.6	29.9	28.5	34.7	35.3	32.3
	Full sample	40.7	40.5	41.8	26.6	26.1	29.0	27.4	26.8	30.5
Weekly carrier	1967–72, 1983–90	22.5	22.2	23.8	12.7	12.3	14.8	9.1	8.9	9.9
	1973–82	22.8	21.6	28.2	14.9	14.0	18.7	18.1	17.2	22.2
	Full sample	22.7	21.9	25.9	13.8	13.1	16.6	13.5	13.0	15.8
Carrier	1967–72, 1983–90	23.3	22.6	28.5	12.3	12.1	13.7	9.4	9.2	10.9
	1973–82	22.6	21.4	29.4	14.2	13.5	18.5	18.2	17.2	24.5
	Full sample	22.9	22.0	29.0	13.2	12.8	16.3	13.8	13.2	18.2
Dealer	1967–72, 1983–90	36.1	35.3	41.4	21.6	20.5	28.8	16.9	15.9	23.2
	1973–82	39.4	38.8	42.3	30.5	30.3	31.1	32.8	32.6	33.7
	Full sample	37.8	37.1	42.0	26.3	25.5	30.2	25.3	24.5	29.5
Mail rate	1967–72, 1983–90	23.0	21.9	29.6	24.9	23.4	34.0	9.5	9.1	12.4
	1973–82	22.5	21.9	24.5	18.9	17.6	23.7	17.4	17.0	19.1
	Full sample	22.7	21.9	26.6	21.8	20.5	28.0	13.6	13.0	16.3

NOTES: 1. The number of price changes for monopolies and oligopolies is, respectively, for the single copy price, 300 and 60; for the weekly carrier price, 615 and 138; for the carrier price, 578 and 88; for the dealer price, 319 and 60; for the mail rate, 611 and 129. 2. The average inflation rate was 4.3% in 1967–72 and 1983–90, 9.6% in 1973–82, and 6.5% in the full sample.

In the remainder of the paper we concentrate on the weekly carrier price. As already discussed, most newspapers are sold by weekly delivery. Single copy price may be dominated by payment convenience, wholesale transaction prices may differ from the reported prices and few newspapers are sold by mail.

2. HOW THE FIRM REVISES THE OPTIMAL POLICY: CONTINUOUS AND DISCRETE APPROACHES

We now turn to a common problem arising from the application of the model to data. The basic Sheshinski and Weiss (1977) model analyzes the optimal policy when inflation is constant[11] and demand and costs are stationary. Under these assumptions the optimal pricing policy never requires revision. In practice, however, they are not met and so the firm needs to revise its optimal policy over time. In empirical work assumptions must be made about the frequency of these revisions.

It is useful to introduce some notation. Assume that a firm (newspaper) i changes prices at times τ_k, $k = 1, \ldots, n$ (to simplify notation, the firm subscript is suppressed). All prices are in logs. Let $p(t)$ denote the log of the nominal price of firm (newspaper) i at time t, $p(\tau_k)$ denote the log of the *new* nominal price set at τ_k, and $P(t)$ denote the log of the aggregate price level at time t. $P(t)$ is assumed to be continuous. Define: $p^{o}(t) = \lim_{\nu \to t^{-}} p(\nu)$. When the price is not changed, we have $p^{o}(t) = p(t)$.

11. See Sheshinski and Weiss (1983), Danziger (1983, 1984), Caplin and Spulber (1987), and Dixit (1991) for the analysis of the optimal policy when inflation is stochastic.

At the time of adjustment $p^{o}(\tau_k) = p(\tau_{k-1})$, i.e. $p^{o}(\tau_k)$ is equal to the (log of) the old nominal price.

Suppose that prices are continuously observed so that the times of adjustment, … τ_{k-1}, τ_k, … are known. The empirical definition of the price bounds depends on how often the firm monitors the economic environment. One possibility is to assume that the firm continuously monitors the economic environment and recomputes the price bounds. In this case, which we call *the continuous approach*, the upper bound is defined as the ratio of the *new* nominal price to the current aggregate price level:[12]

$$S^{c}(\tau_k) = p(\tau_k) - P(\tau_k) \tag{1}$$

where $S^{c}(\tau_k)$ denotes the log of the upper bound under the continuous approach. Similarly, the lower bound, $s^{c}(\tau_k)$, is defined as the ratio of the *old* nominal price to the current aggregate price level:

$$s^{c}(\tau_k) = p^{o}(\tau_k) - P(\tau_k) = p(\tau_{k-1}) - P(\tau_k) \tag{2}$$

where the last equality uses the definition of $p^{o}(\tau_k)$.

An alternative, which we call *the discrete approach*, is for the firm to determine the optimal pricing policy at the time of adjustment and monitor only the aggregate price level. When its current real price falls below the lower bound set at the time of the previous adjustment, the firm collects information, reevaluates its pricing policy and changes the nominal price. The upper bound is the same as under the continuous approach: $S^{c}(\tau_k) = S^{d}(\tau_k)$.[13] The lower bound is equal to the ratio of the *new* nominal price to the value of the aggregate price level at the time of the *next* price change:

$$s^{d}(\tau_k) = p(\tau_k) - P(\tau_{k+1}) \tag{2'}$$

where the superscript d denotes the optimal price bounds under the discrete approach.

Under the continuous approach the time to the next adjustment is affected not only by the inflation rate but also by the revisions of the lower bound. The price bounds, $S^{c}(\tau_k)$ and $s^{c}(\tau_k)$, are revised at every instant; they are in effect only at τ_k. On the other hand, under the discrete approach, the time to the next price change is affected only by the inflation rate. The price change at τ_k is triggered when the current real price falls below $s^{d}(\tau_{k-1})$–the lower bound set at the time of the *previous* price change. This prompts the firm to reevaluate its pricing policy and set the new bounds, $S^{d}(\tau_k)$ and $s^{d}(\tau_k)$, which remain unchanged on the interval $[\tau_k, \tau_{k+1})$.

Empirically, the lower bound can only be calculated at the time of the next price change, τ_{k+1}, as the ratio of the new nominal price at τ_k to the aggregate price level

12. Columns (b) in Tables 2 and 3 are computed using the continuous approach. Dividing the data into different periods would require additional assumptions and elimination of a large number of observations.

13. Note, however, that the empirical estimates of $S^{c}(\tau_k)$ and $S^{d}(\tau_k)$ are different, as the two approaches use different configurations of the data. We discuss this issue in Section 4.1.

at τ_{k+1}. In contrast, under the continuous approach, the lower bound can be computed at τ_k as the ratio of the old nominal price to the current aggregate price level. As a consequence, the definition of the size of price change as well as the empirical definition of the time between price changes differ between the two approaches. In particular it means that the average size of a price change under the continuous approach is given in Columns (b) of Tables 2 and 3 while, under the discrete approach, it is equal to the average elapsed inflation since the last price change (Columns (c)).

Still another alternative is a periodic revision policy; for example information is collected, and pricing policy reevaluated, once a year (Zbaracki et al. 2004, describe such time-contingent approach to pricing). The length of the revision period would depend on the costs of reevaluation and the volatility of the economic environment. It may be longer than the period between price changes.[14]

As we do not have the information required to choose between the alternative approaches, we test the model under both the continuous and the discrete assumptions.[15] It is useful to note that, as a newspaper company sets a limited number of prices, it is more likely than most other firms to use the continuous approach.

3. DATA ISSUES

3.1 Infrequent Observation Bias

If nominal prices are not continuously observed, the τ_k's are not known. This generates a bias, which we will call the *infrequent observation bias*, in the estimation of the price bounds. To illustrate, assume that observations take place at t^j, $j = 1, \ldots, m$, where m is common to all firms and that there is, at most, a single price change between observations. Let t_k^j denote a situation in which the kth price change is observed at time j. Whenever we observe t_k^j we know that $t_k^{j-1} < \tau_k < t_k^j$, i.e., that the kth price change took place between the times t^{j-1} and t^j.

The standard procedure is to compute the price bounds (assuming, for example, the continuous approach; the situation is analogous for the discrete approach) as:

$$\hat{S}^c(t_k^j) = p(t_k^j) - P(t_k^j) \tag{3}$$

$$\hat{s}^c(t_k^j) = p^o(t_k^j) - P(t_k^j) \tag{4}$$

where a hat denotes the empirical value. But the correct values for the price bounds are given by Equations (1) and (2), rather than by Equations (3) and (4). The bias for the upper bound is:

$$\begin{aligned}\hat{S}^c(t_k^j) - S^c(\tau_k) &= [p(t_k^j) - P(t_k^j)] - [p(\tau_k) - P(\tau_k)] \\ &= P(\tau_k) - P(t_k^j) = \int_{\tau_k}^{t_k^j} \Pi(t)dt \end{aligned} \tag{5}$$

14. For example, in the stochastic environment considered by Sheshinski and Weiss (1983), the optimal period between revisions is infinite even though inflation changes over time.

15. Note that we do not consider the possibility that, at t_k, the firm plans a reevaluation of its policy at $t_k < t' < t_{k+1}$ and, following the data collection, decides to keep the price unchanged. The reason is that under such policy, which is, essentially, a mixture of the discrete and continuous approaches, t' is never observed.

and similarly for the lower bound.[16] Here $\Pi(t)$ is the rate of inflation; the second equality uses the fact that, given the assumption of one price change between t_k^{j-1} and t_k^j, we have $p(t_k^j) = p(\tau_k)$ and, for the lower bound, $p^o(t_k^j) = p^o(\tau_k)$.

Since $\tau_k < t_k^j$, both price bounds are biased downwards. If the distribution of τ_k in the interval (t_k^{j-1}, t_k^j) is independent of the inflation rate, which is a sensible assumption, the infrequent observation bias creates negative correlation between inflation and the price bounds. This bias is common to all studies in which prices are not continuously observed and it increases with the length of the period between observations.

To avoid the infrequent observation bias we assume throughout that, whenever we observe the kth price change, it took place at time $\hat{\tau}_k = (t_k^j + t_k^{j-1})/2$.

3.2 Multiple Price Changes between Observations

When prices are not observed continuously, it is possible that more than one price change takes place between consecutive observations.[17] Assume that, as empirical evidence suggests, the frequency of price changes rises with expected inflation. This creates a bias in the estimated coefficient of inflation on the size and on the frequency of adjustment: the coefficient on the size is too high, and the coefficient on the frequency is too low. This problem cannot be avoided unless all prices are reported, as is the case with catalogue data (Kashyap 1995) or when prices are regulated (Sheshinski, Tishler, and Weiss, 1981, Dahlby, 1992). Our empirical results suggest that there are, indeed, a few instances of multiple price changes between observations.

4. PARAMETRIC TESTS OF THE BASIC MODEL

4.1 Empirical Approach

We estimate reduced-form equations by a two-stage procedure using both the continuous approach and the discrete approach. The optimal levels of s and S are determined by the first-order conditions as functions of the exogenous variables. The linear approximations of these functions are:

$$S(t) = \beta_1' x(t) + \varepsilon(t), \quad s(t) = \beta_2' x(t) + u(t)\,, \tag{6}$$

where $x(t)$ is the vector of exogenous variables, discussed below, and β_1 and β_2 are coefficient vectors. The random variables $\varepsilon(t)$ and $u(t)$ represent shifts in the profit function due to unobserved changes in cost and demand conditions. We assume that

$$[\varepsilon(t), u(t)] \sim \text{bivariate normal } (0,0,\sigma_e^2,\sigma_u^2,\rho)\,. \tag{7}$$

16. The bias for $\hat{s}^c$ and $\hat{S}^d$ is given by the integral in Equation (5); the bias for $\hat{s}^d$ is $\int_{t_{k+1}}^{t_{k+1}^n} \Pi(t)dt$ where $(k + 1)$th price change is observed in the nth observation.

17. See Danziger (1987) for a discussion of this issue.

Under the continuous approach, the probability that newspaper i changes its nominal price at time t is:

$$\Pr[p(t) \geq p^o(t)] = \Pr[u(t) \leq -p^o(t)/P(t) + \beta_2' x(t)] . \quad (8)$$

Estimates of σ_u and the coefficient vector β_2 can be obtained by maximizing the likelihood function:

$$L = \prod_{t \in I_A} \Phi\{[-p^o(t)/P(t) + \beta_2' x(t)]/\sigma_u\} \prod_{t \in I_B} \{1 - \Phi\{[-p^o(t)/p(t) + \beta_2' x(t)]/\sigma_u\}\} ,$$

where I_A denotes the set of observations for which $p(t)$ has increased, I_B denotes the set of observations for which $p(t)$ is unchanged, and Φ is the standard normal distribution function.

It is convenient to re-parameterize the model by defining $\theta \equiv -1/\sigma_u$ and $\gamma \equiv (1/\sigma_u)\beta_2$. The likelihood function then becomes:

$$L = \prod_{t \in I_A} \Phi[\theta p^o(t)/P(t) + \gamma_2' x(t)] \prod_{t \in I_B} \{1 - \Phi[p^o(t)/P(t) + \gamma_2' x(t)]\} .$$

The similarity of this likelihood function to that of a probit model is obvious, so maximization is routine.[18] After estimation of $[\gamma, \theta]$, estimates of $[\beta_2, \sigma_u]$ can be recovered as $\beta_2 = -(1/\hat{\theta})\hat{\gamma}$ and $\hat{\sigma}_u = -1/\hat{\theta}$. The asymptotic covariance matrix is estimated as $\hat{J}\hat{V}\hat{J}$, where $\hat{V}$ is the estimated covariance matrix from the probit model and $\hat{J}$ is the estimator of the derivatives matrix:

$$J = \begin{bmatrix} \partial\beta/\partial\theta' & \partial\beta/\partial\theta \\ \partial\sigma_u/\partial\theta' & \partial\sigma_u/\partial\theta \end{bmatrix} = \begin{bmatrix} -1/\theta & \gamma/\theta^2 \\ 0' & 1/\theta^2 \end{bmatrix} .$$

Recalling that $S(t) = p(t)/P(t)$ whenever a price change occurs, we can then obtain consistent estimates of ρ, σ_ε, and the coefficients of β_1 from the regression:

$$p(t)/P(t) = \beta_1' x(t) + \rho\sigma_\varepsilon\lambda(t) + \omega(t), \quad \text{for } t \in I_A . \quad (9)$$

The variable $\lambda(t)$ is the inverse Mill's ratio calculated from the probit estimation and is included to eliminate the sample selection bias. With this definition, the residual $\omega(t)$ has an expectation equal to zero.

In the discrete case the probability that newspaper i changes its nominal price at time t is:

$$\Pr[p(t) > p^o(t)] = \Pr[u(t_{k-1}) \leq -p^o(t)/P(t) + \beta_2' x(t_{k-1})] ,$$

recalling that $s^d(t_{k-1})$ is the lower bound set at the time of the previous price change.

Finally, the (conditional) size of a price change is given by:

$$S(t_k) - s(t_k) = (\beta_1 - \beta_2)' x(t_k) + \varepsilon(t_k) - u(t_k) . \quad (10)$$

18. The model contains an additional term not present in the standard probit model, namely the term $p^o(t)/P(t)$. The presence of this term allows us to estimate the variance of the disturbance term, σ_u, which cannot be estimated in the standard probit model.

For the purpose of estimation, an additional issue should be noted. For probit estimation, the crucial difference between the discrete and continuous approaches is that the values of the explanatory variables change with each observation in the continuous case, whereas they change only with each price change for the discrete case. This simply reflects the fact that, in the discrete case, the optimal price is determined only at the time of adjustment. In between price adjustments, subject to this decision, the firm monitors only the aggregate price level. Since the probit regressions are different, the Mill's ratio differs between the continuous and discrete cases, which implies that the upper bound regressions will yield different estimates in the two cases.

4.2 Explanatory Variables

If the assumptions of the basic model were met, empirical tests would involve regressing the price bounds, as well as the frequency of price changes, on the actual inflation rate (equal to the expected inflation rate) and the real interest rate. As the assumptions are not met, we need to accommodate the influence of other variables on the price bounds and the frequency of price changes, as well as take into account the data considerations discussed in the previous sections. We test the optimal pricing policy under both the continuous and discrete approaches. To avoid the infrequent observation bias we assume, in the absence of priors, that the date of each price change is in the month halfway between observations.

For expected inflation we use nationwide survey data from Laxton, Rose, and Tetlow (1993). The data, used also in Dahlby (1992), are from *Canadian Business Review*. They are based on a survey of forecasts by banks and private consulting companies. While there exist more econometrically sophisticated measures of expected inflation, we think the survey data are closer to the forecasts used by firms in determining the optimal pricing policy. Professional forecasts generally do a better job than individuals in predicting inflation (Carroll 2003). They are widely available and their use reduces information costs in determining the optimal pricing policy.

These expectations are also used to calculate the real interest rate.[19] The model implies that the higher is the real interest rate, the lower are both price bounds. The intuition is as follows: since the firm maximizes the present discounted value of profits, a higher real interest rate increases the importance of profits immediately following the price change and reduces the importance of profits at the end of the pricing cycle. As the optimal policy implies $s < z^* < S$, where z^* is the instantaneous profit maximizing price, a higher real interest rate leads to a reduction of both price bounds.

In addition, we include on the right-hand side the time since the last observation, the size of the previous price change, the change in newsprint price, the index of

19. The data sources are as follows. The change in newsprint price is Cansim series D691618. The real newspaper price index is the ratio of the newspaper price index (Cansim series P484467) to CPI for all items (Cansim series P484000). The level of sales is the level of own circulation, from the Audit Bureau of Circulation (ABC). The real interest rate is obtained using the nominal interest rate on 90-day prime corporate paper (Cansim series B14017).

real newspaper prices, the change in sales (change in own circulation), and the level of sales (the level of own circulation), as well as dummy variables for each year and each newspaper.

The time since the last observation is included to control for the irregular timing of observations. A long period between observations increases the chance of multiple adjustments. If multiple price changes take place between observations, the coefficient on the time since the last observation on adjustment size should be positive and the coefficient on the lower bound should be negative; on the other hand the time since the last observation should have no effect on the upper bound. A large previous price change may indicate a firm with large adjustment costs; in that case we expect a low probability of adjustment, a large price change, and low frequency. Alternatively, a large previous price change may mean the firm made a mistake, increasing the price too much; in that case (as there are no price decreases in our data) we expect a long period to the next price change.

The next three variables are included as a proxy for the optimal frictionless price. A higher frictionless price implies, *ceteris paribus*, a lower probability of adjustment and larger price bounds. Newsprint price data are used as a proxy for costs; as a rough guide, newsprint costs constitute about a quarter of total production and distribution costs. The newspaper price index is a proxy for cost factors other than newsprint as well as for other trends in newspaper prices. The change in own circulation measures the change in demand.

There are two reasons to include the level of circulation as an explanatory variable. First, monopoly firms have, on average, significantly smaller circulation than oligopolies. Second, while the relationship between firm size and frequency of price changes is, in general, ambiguous (Konieczny and Skrzypacz 2004), it is likely that it is positive in the newspaper market.[20] Finally, year and newspaper dummies are included to allow for year and firm-specific fixed effects not captured by the other explanatory variables. Note that year dummies are not observation-specific as there are several observations each year.

4.3 Regression Results

In Figure 1 we show the scatter plots of expected inflation and the average size of price adjustment, separately for the two approaches (the graphs for the median adjustment size are similar). It is clear that the size of adjustment increases with expected inflation, and the relationship is much stronger when the discrete approach is used.

This is confirmed by regression results in Table 4 which also indicate that price behaviour of the two types of firms is similar. Under the discrete approach the results for monopolies are consistent with the model. Higher inflation means lower s, higher S, and a larger price change; except for the upper bound the results are significant

20. Konieczny and Skrzypacz (2004) show that the relationship is, in general, ambiguous. It is positive if firms face constant marginal costs and differ by demand only. Buckle and Carlson (2000), using survey data from New Zealand, find a positive relationship between firm size and the frequency of price adjustment.

TABLE 4

REGRESSION RESULTS

Pricing Policy	Discrete		Continuous	
Type of Firm	Monopoly	Oligopoly	Monopoly	Oligopoly
Lower Bound				
Expected inflation	−0.0327**	−0.0391*	0.0368	−0.1013
Real interest rate	0.0275**	0.0099	0.0223	0.0667
Time since last observation	−0.0353**	−0.0479*	−0.0165	−0.0350
Previous price band	0.1213	0.2826	0.0485	0.5215
Real industry price	0.0202**	0.0323*	0.0226	0.1119**
Change in costs	−0.0009	−0.0020	0.0055*	0.0057
Change in circulation	0.0001	0.0001	0.0075*	0.0000
Level of sales	0.0015	0.0030	0.0042*	0.0048
$Sigma_u$	0.1836**	0.2786*	0.3443*	0.4811**
Upper Bound				
Expected inflation	0.0026	−0.0556	0.0270	−0.1297
Real interest rate	0.0020	0.0120	0.0171	0.1101
Time since last observation	0.0104	−0.0212	−0.0076	−0.0330
Previous price band	−0.3447**	0.2392	0.1576	0.8787
Real industry price	0.0029	0.0200	0.0210	0.1296*
Change in costs	0.0014	−0.0022	0.0036*	0.0084
Change in circulation	−0.0005	−0.0023	0.0044	−0.0005
Level of sales	0.0007	0.0048	0.0030*	0.0091
λ	0.1234**	0.2565*	0.3261*	0.7547**
Size of Adjustment				
Expected inflation	0.0353**	−0.0164	−0.0098	−0.0284
Real interest rate	−0.0255**	0.0021	−0.0052	0.0434
Time since last observation	0.0457**	0.0267	0.0089	0.0020
Previous price band	−0.4660**	−0.0434	0.1091	0.3572
Real industry price	−0.0173**	−0.0123	−0.0016	0.0177
Change in costs	0.0024	−0.0001	−0.0019	0.0027
Change in circulation	−0.0006	−0.0023	−0.0031	−0.0005
Level of sales	−0.0008	0.0018	−0.0012	0.0044
Time between Price Changes				
Expected inflation	0.349	1.467	−1.695	−0.027
Real interest rate	0.141	−2.124*	−1.526*	−0.291
Time since last observation	−0.389	−0.407	0.510	−0.461
Previous price band	−6.358	2.279	21.622*	0.163
Real industry price	0.566	−0.417	−1.434*	−2.416**
Change in costs	−0.009	−0.245	0.578*	0.787**
Change in circulation	−0.244*	0.268*	−0.219	0.054
Level of sales	0.113*	0.079	−0.107*	−0.008
λ	6.772**	11.309*	16.010*	−5.835

NOTE: **denotes statistical significance at 1% level; *at 5% level.

at the 5% level.[21] For oligopolies, the effect of expected inflation on the lower bound is as predicted (and significant at 5% level) while the effects on the upper

21. A possible explanation of the insignificant result for the upper bound is as follows. In case of newspaper prices, payment convenience is important. Indeed, nominal prices are almost always a multiple of five cents and often multiples of 25 cents. Given the need to charge convenient prices, when adjustment takes place the firm chooses the closest convenient price and the observed real price is equal to that price divided by the aggregate price level. Hence the observed value of real price immediately following adjustment differs from the upper bound, *S*. This introduces noise in the data. Of course, this explanation assumes a different approach to setting the lower and upper bound.

bound and adjustment size are of the wrong sign but not significant. As there are fewer oligopolies (13) than monopolies (51) in our data, the lack of statistical significance is not surprising.

Under the continuous approach, however, the effect of expected inflation on the size of adjustment is of the wrong sign for both types of firms and so is the effect on the lower bound for monopolies and on the upper bound for oligopolies. None of the coefficients on the expected inflation rate or on the real interest rate is significant. A researcher who estimates only the continuous case (as existing studies do) would likely conclude that the data do not support the costly price adjustment model.

The effect of the real interest rate is different than implied by the simple model: a higher real interest rate increases both price bounds and the effect is significant for the lower bound in the discrete approach. This is similar to the result obtained by Sheshinski, Tishler, and Weiss (1981); no other study analyses the effect of the real interest rate on the price bounds. It is possible that our measure of the real inflation rate is not relevant in the newspaper market. Perhaps more importantly, firms that follow nominal accounting rules may not pay as much attention to discounted real profits as economic theory suggest they should.

The effect of other explanatory variables are as predicted. For monopolies in the discrete case the results indicate that there are instances of multiple price changes between observations: the longer is the time since the last observation, the larger is the size of adjustment and the smaller is the value of the lower bound (significant at the 1% level) while the effects on the upper bound are not significant.[22] A large previous price change reduces the size of adjustment in the discrete case; the effect is significant at the 1% level for monopolies. This indicates that large price changes are not due to large adjustment costs.

Whenever the effect of variables influencing the frictionless optimal price is significant, it is as predicted by Cecchetti (1986): higher frictionless price implies larger values for both price bounds. The effect of changes in circulation indicates further that the behaviour of monopolies and oligopolies differs. An increase in circulation shortens the time between price changes for monopoly papers but lengthens it for oligopoly firms; these effects are significant under the discrete approach. Finally, year and newspaper dummies are jointly significant, indicating that the explanatory variables do not capture all differences in optimal pricing policies across time and across firms.

A question that arises naturally from the results in Table 4 is whether there is a statistical difference between the coefficient estimates from the monopoly and oligopoly regressions. To test the hypothesis that the coefficients are equal, we pool the two samples and re-estimate the lower bound (probit) regression. The pooled regression restricts the coefficient estimates for the variables in Table 4 to be the same for monopoly and oligopoly firms and is nested in the unrestricted regressions

22. In the discrete case, longer time between observations reduces the lower bound for oligopolies as well. On the other hand, in the continuous case the effects are not significant.

displayed in Table 4. The likelihood ratio χ^2 test statistic has a value of 48.45 in the discrete case with 20 degrees of freedom.[23] The critical value is 37.57 at the 1% level, so the hypothesis that the coefficient estimates for monopoly and oligopoly firms are the same is easily rejected (results in the continuous case are similar).

Another way of exploiting the pooled data is to use a dummy variable to look for differences across firm types. We estimate two additional pooled lower bound regressions for the discrete and continuous cases. The first simply includes a dummy variable for oligopolies; the second includes a variable that interacts the oligopoly dummy variable with expected inflation. For both regressions and both the discrete and continuous cases, the log likelihood values barely change from their pooled values and the coefficient estimates for the added variables are smaller than their respective standard errors. We conclude that, while the estimates between monopolies and oligopolies are statistically different, the differences are not due to the effect of expected inflation alone.

5. CONCLUSIONS

Our analysis points out that testing the basic costly price adjustment model is difficult as many assumptions are not met in the data. The goal of the paper was to examine if the rejections of the basic costly price adjustment model are due to this problem. The contribution of the paper is twofold. First, we analyse monopoly firms. Second, we ask how a firm may approach the determination of the optimal pricing policy in a nonstationary environment.

In our data set it turns out that the second issue is more important. A researcher who assumes infrequent reevaluation of the optimal pricing policy would conclude that data provide strong support of the model. On the other hand, a researcher would reject the model under the assumption of continuous adjustment of the optimal pricing policy. The distinction between monopoly and oligopoly firms is less important. While their pricing behaviour is different, there are few significant differences of the effect of expected inflation on the optimal pricing policy of the two types of firms.

Both results support the model. Earlier studies assumed continuous adjustment of the optimal pricing policy. As argued above, the discrete approach allows the firm to reduce information costs. It should be noted that, as a newspaper firm sets few prices, its information costs are lower than for most other firms. Therefore our results indicate that, when the costly price adjustment model is tested using data from grocery chains, drugstores, catalogue firms, industrial companies etc., the discrete approach should be used alongside the continuous assumption. The fact that the effect of inflation on price behaviour of monopolies and oligopolies is similar indicates that the basic model, which derives the results for monopolies only, may apply to other market structures as well.

23. There are 20 degrees of freedom owing to the eight variables listed in Table 4 (time since last observation through to expected inflation) and the 12-year effects.

Konieczny and Skrzypacz (2004) provide a different explanation for the occasional rejections of the simple costly price adjustment model. They develop a model in which firms face costs of changing nominal prices and customers search for the best price. The model implies that the more intensive the search for the best price in a given market, the more frequent and smaller are price changes. They test these predictions using a large disaggregated data set. The cross-sectional results for the 52 goods in their sample provide strong support for the model. On the other hand, when markets are analysed individually, the model is rejected in about 20% of the cases. They conclude that price behaviour is idiosyncratic. While market-specific features may dominate price behaviour for individual goods, they "average out" over many goods and so the costly price adjustment model does hold at the aggregate level.

The costly price adjustment approach has been criticized because the literal *menu cost* of changing nominal prices (changing labels, informing salesmen and customers etc.) appears small. Our results provide unqualified support for this criticism. For newspapers, the costs of printing a new price are zero, while the costs of informing salesmen and customers are, presumably, quite small. Literal menu costs cannot be responsible for the substantial rigidity of nominal prices observed in the data. Thus, as suggested by Ball and Mankiw (1994), calling the adjustment costs "menu costs" is misleading.

The important costs of price adjustment are the costs of the decision process and the costs of unfavourable reaction of competitors and/or customers to nominal price changes. Our results for monopolies suggest that the costs of unfavourable customer reaction to price changes, hypothesized by Rotemberg (2002), are important. These costs appear similar for similar goods: the adjustment size for the single copy price is almost identical to the average size of price changes (25%) for the single copy magazine price in Cecchetti (1986).

While studying the individual pricing policies is interesting on its own, macroeconomic implications of sticky prices, as stressed by Ball and Mankiw (1994), are more important. This analysis is difficult because aggregate models based on costly price adjustment are much more difficult to solve than models that assume perfectly flexible prices. Recently there has been great progress in aggregating the discontinuous price behaviour of monopoly firms. The results of our paper point out that the next step is to analyse optimal price behaviour in oligopoly markets.

Further progress in empirical testing imposes, therefore, two requirements on the data: they should pay closer attention to the assumptions of the basic model and provide some idea on the nature of adjustment costs.

Appendix. List of Newspapers

1. Monopolies

Belleville Intelligencer, Brandon Sun, Brantford Expositor, Brockville Recorder and Times, Cambridge Daily Reporter, Charlottetown Guardian, Charlottetown Patriot, Cornwall Standard–Freehold, Fredericton Daily Gleaner, Granby La Voix de L'est, Guelph Daily Mercury, Hamilton Spectator, Kelowna Courier, Kingston

The Whig–Standard, Kitchener–Waterloo Record, London Free Press, Medicine Hat News, Moncton Times–Transcript, Moose–Jaw Times Herald, Nelson Daily News, Niagara Falls Evening Review, North Bay Nugget, Oshawa The Times, Ottawa Le Droit, Owen Sound The Sun Times, Pentincton Herald, Peterborough Examiner, Prince George Citizen, Red Deer Advocate, Regina Leader Post, Sarnia Observer, Saskatoon Star–Phoenix, Sault Ste. Marie The Sault, Sherbrooke La Tribune, Simcoe Reformer, St. Catharines The Standard, St. John's Evening Telegram, St. Thomas Times–Journal, Stratford Beacon Herald, Sudbury Daily Star, Summerside Journal–Pioneer, Sydney Cape Breton Post, Thunder Bay The Chronicle, Thunder Bay The Times News, Trois Rivieres Le Nouveliste, Truro Daily News, Vancouver Province, Vancouver Sun, Welland–Port Colborne Evening Review, Windsor Star, Woodstock Sentinel–Review.

*2. Oligopolies**

Calgary Herald, Edmonton Journal, Halifax Chronicle–Herald, Halifax Mail Star, Montreal Le Devoir, Montreal Gazette, Montreal La Presse, Ottawa Citizen, Quebec Le Soleil, Saint John Evening Times Globe, Saint John Telegraph–Journal, Toronto Globe & Mail, Toronto Star, Winnipeg Free Press.

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*As we have data for only 64 out of about 100 daily newspapers in Canada, for some cities (for example Calgary) our data cover only one of the several papers. We assume that the French and English language newspapers in Quebec and in Ottawa are not close substitutes; hence Ottawa Le Droit is treated as a monopoly while Ottawa Citizen is an oligopoly as another English-language daily (Sun) was sold there.

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