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Abstract

This paper assesses the impacts of the Northeast Dairy Compact (NEDC) and retail oligopoly power on fluid milk prices in Boston. Empirical results reveal that price increases due to oligopoly power outweighed those caused by the NEDC by nearly seven times. In fact, markups are estimated at approximately 25% of the retail milk price, translating into approximately a little less than $0.75/gallon. We also estimated that only around two-thirds of the raw milk price changes were passed forward to consumers. This helps explain why consumer prices have come down only little after elimination of the NEDC. In fact, the new milk income loss contract program, which basically provides partial price subsidies to farmers, has contributed to low raw milk prices that have generated substantial benefits to milk processors and retailers, modest benefits to farmers and consumers, all at the expense of taxpayers.

Key words: market power, public policy, price transmission, milk, regulation, Dairy Compact

JEL classification: L66, L11, L13

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1. Introduction

Boston consumers pay considerably more for milk than their counterparts in many other major cities in the Northeast (e.g., New York City). Researchers and policy makers have pointed to one of two culprits as the cause of supra-normal retail prices: (a) the *de facto* exercise of market power through public policies such as the Northeast Dairy Compact (NEDC) that increase the price of raw milk paid to farmers (Bailey, 2003; Balagtas and Sumner, 2003; Cotterill and Franklin, 2001; Lass et al., 2001) and (b) the exercise of private market power--the ability of firms to control price or quantity in the marketplace--by Boston supermarkets (Cotterill, 2003; Kilman, 2003; Cotterill and Dhar, 2003; Mohl, 2002).

The Boston milk market situation is common in many market channels. Private market power in processing and retailing often coexists with public policies that affect milk prices. For a fair and balanced policy analysis, therefore, such situations require a comprehensive model that takes into account both private market power and public policies. In this context, relevant policy questions include: What are the independent and joint impacts of private market power and raw milk price policies in explaining high consumer prices for milk in Boston? What is the relative importance of one vs. the other? When the raw milk price drops, how much of the decrease is passed on to consumers and how much is captured into a larger marketing margin?

This article pursues two objectives: The first is to test for and measure oligopoly power in the Boston milk market channel, and the second is to assess the joint and independent impacts of private market power and of the NEDC on retail prices for fluid milk in Boston. The analysis is based on the oligopoly model of Appelbaum (1982) and the ensuing measures of private market power, demand, marginal cost, and the farm-retail price transmission within this structural model. Counterfactual experiments are also conducted to simulate the alternative scenarios with and without private market power and/or the NEDC.

Empirical findings indicate that approximately 25% of the retail price (or a little less than $0.75/gallon) is due to private market power and that although the NEDC did increase the retail price of milk, the impact due to private market power is nearly seven times larger. In addition, a partial passthrough of the cost of milk helps explain why consumer prices have not come down after the elimination of the NEDC, ironically a flagship argument used in its political defeat (International Dairy Foods Association, 2001; National Center for Policy Analysis, 2001; Wall Street Journal, June 20, 2001).

2. The Boston Fluid Milk Market

The Boston fluid milk market provides a useful case study for a number of reasons. Public policies in that market have stirred hot debate in policy and research arenas, particularly regarding the NEDC, which established a price floor for raw milk--a public exercise of market power.[1] This policy co-existed with increasingly concentrated milk processing and retailing sectors that have raised private market power concerns. The Boston milk case also illustrates a more general class of economic problems where the relationship between primary producer and retail prices appears to be increasingly tenuous.[2]

In the presence of intense opposition by milk retailing and processing industries and Midwest dairy farm groups, the NEDC was dismantled in September 2001. The zero-cost to taxpayers feature of the NEDC has been replaced by the Milk Income Loss Contract program.[3] This program, based on the Boston raw milk price, provides a partial subsidy to dairy producers nationwide and lowers the acquisition price for raw milk paid by fluid milk processors. It benefits consumers to the extent that the cost savings are passed on to them, though in New

England and many other regions this has clearly not happened (Mohl, 2002; Kilman, 2003; Brasher, 2000).

Notably, concentration is taking place in milk processing in the Boston area. By 1999 Dean Foods became the leading fluid milk processor in the Boston area, accounting for approximately 88% of the milk processing capacity in New England (GAO, 2001).[4]

An important feature of channel milk pricing in the Boston area, as in many other areas in the country for that matter, is that milk processing on behalf of the retailers is based on cost-plus contracts whereby processors charge a fixed markup over the cost of raw milk in a multi-year contract setting (Cotterill and Tian, 2004).[5] Milk processing contracted this way accounts for approximately 85% of the milk sold in Boston, including all private label and Garelick brands. According to cost engineering estimates by Dairy Technomics, milk-processing charges in Southern New England averaged approximately $0.60 over the raw milk price in 2003 (Cotterill et al., April 2003, Appendix A). Dalton et al. (2002) estimate them at $0.45/gallon in 2000 for the state of Maine.

At the retail level, the market share of the four top supermarkets (Stop & Shop, Shaw's, DeMoulas, and Star Market) in the Boston area increased from 55% to 70% between 1997 and 1999 (GAO, June 2001). By July 2000, these supermarkets controlled more than 84% of fluid milk sales (Table 1) with Stop and Shop, the market leader, controlling 40% of the market in 2003 (Cotterill, 2003).

The supermarkets are clearly the channel captains in the Boston milk market. Their private label milk accounts for nearly 70% of total supermarket milk sales. This high percentage of private label milk gives them more discretionary pricing power over consumers and may perhaps give them some power over processors as well (Narashiman and Wilcox, 1998) when setting multi-year cost-plus contracts. In addition, retail milk prices across brands and across supermarket chains appear to be highly coordinated. Using the four-weekly data from Information Resources Incorporated-Infoscan (IRI), the partial correlation coefficient of the retail milk prices for these supermarkets ranges from 0.94 to 0.98, and they move together to a great extent, as shown in Figure 1. Finally, through enhanced retail configuration, supermarkets are able to capitalize on consumers' desire for one-stop shopping when buying necessities such as milk (Bonanno and Lopez, 2003). Thus, high supermarket prices for milk do not cause consumers to switch to other retail outlets that may offer lower milk prices.

High supermarket milk prices have persisted in the Boston area even in the face of historically low raw milk prices (Cotterill, 2003). In fact, as Figure 1 shows, the correlation between the average retail price and the average raw milk price for milk is rather weak. The coefficient of partial correlation, although positive, is 0.395. The foregoing suggests the exercise of substantial oligopoly power by milk retailers in Boston.

3. The Model

The Boston milk market channel has both processors and retailers beyond the farm gate that compete vertically with each other as well as horizontally in their respective markets to capture channel profits. Consider several stages of the vertical market channel for fluid milk in Boston. Farmers sell their milk to processors at prices fixed by Federal regulation (Federal Milk Marketing Order) or the Dairy Compact plus possible over-order premia. Milk processors collect the milk, process the raw milk into bottled milk and butterfat, and deliver it to the docks of supermarkets. Thus, processors sell fluid milk to supermarkets under cost-plus contracts (the raw milk price plus a processing margin, as is in fact the case for most fluid milk in Boston). Supermarkets then sell the milk to Boston consumers. This study focuses on oligopoly power in the latter stage and on the price transmission of raw milk prices to the consumers in reference to the NEDC.

Consider then a fluid milk industry in which N firms distribute a homogeneous good. Total industry output is given by $Q = \sum_{i=1}^{N} q_i$, where q_i is the quantity of milk supplied by supermarket *i*. Let the market demand facing the supermarket industry be given by:

$$Q = f(p_r, Z), \qquad (1)$$

where p_r is the retail price of milk and Z is a vector of demand shifters.

The variable profits made by the i[th] retailer are given by:

$$\pi_i = p_r q_i - c_i(q_i, p_w, W^R), \qquad (2)$$

where p_w is the wholesale price charged by milk processors, and $c_i(q_i, p_w, W^R)$ is the cost of distributing milk incurred by the i[th] firm, and W^R is a vector of prices for non-milk inputs incurred in retailing fluid milk.

The first order condition for maximization of (2) yields:

$$p_r = \frac{MC_i}{1 + \frac{\theta_i}{\eta}}, \qquad (3)$$

where MC_i $(= \partial \ln c_i / \partial \ln q_i)$ is the marginal cost, θ_i is a conjectural variation elasticity $(= \partial \ln Q / \partial \ln q_i)$ and η is the price elasticity of market demand $(= \partial \ln Q / \partial \ln p_r)$.

To infer market power with market level data, two issues arise from equation (3): the aggregation of marginal costs and the aggregation of conjectural variation elasticities across firms. As is standard in the literature (Sexton and Lavoie, 2001), we assume a Gorman polar form so that marginal costs are constant across firms without implying that their cost functions are identical ($MC_j = MC$). Then, as long as the assumption of constant total marginal cost is maintained, at equilibrium the conjectural elasticities are the same for all retailers $(\theta_j = \theta)$. The industry-level Lerner index of oligopoly power is, therefore, given by $L = -\theta / \eta$.

The null hypothesis to test for retail market power concerns the market conduct parameter θ and the Lerner index. We also seek to measure whether industry conduct changed with the implementation of the NEDC. Was the NEDC a focal point event that supermarkets used to significantly elevate the degree of tacit collusion?

In order to evaluate the impact of the implementation of NEDC on pricing conduct, the parameter θ is allowed to vary with a NEDC dummy variable (*NEDC*). Assuming the marginal cost to be a linear function of retail input prices, equation (3) becomes:

$$p_r = \frac{\tau p_w + \sum_{j=1}^{m} \beta_j W_j^R}{1 + \frac{(\theta_0 + \theta_1 NEDC)}{\eta}} + \varepsilon_1, \qquad (4)$$

where the numerator is the retail marginal cost which is a function of the wholesale milk price and milk retailing inputs. The terms τ and $\beta_j . \theta_0, \theta_1$, and η are parameters and ε_1 is a random error in optimization.

Since nearly all milk is processed under cost-plus contracts, let the following relationship define the contracted wholesale price:

$$p_w = p_f + \lambda, \qquad (5)$$

where p_f is the raw milk price and λ is a fixed processing margin over the acquisition price of raw milk. The margin is assumed to be a linear function of n processing input prices given by $\lambda = \gamma_0 + \sum_{i=1}^{n} \gamma_i W_i^P$. Substituting this expression into (5) and then into the retail marginal cost in the numerator of (4), $MC = \tau p_f + \overline{\beta}_0 + \sum_{i=1}^{n} \overline{\beta}_i W_i^P + \sum_{j=1}^{m} \beta_j W_j^R$, where $\overline{\beta}_i = \tau\gamma_i (i = 0,...,n)$. For simplicity, lump the vector of non-milk input prices used in processing and retailing into $W = \{W^P, W^R\}$ and combine $\overline{\beta}_i$ and β_j into a single vector of parameters (also note that some input prices, such as electricity and variable capital services may affect both stages of production). Subsequently, one obtains the following retail pricing equation:

$$p_r = \frac{\tau p_f + \beta_0 + \sum_{i=1}^{n+m} \beta_i W_i}{1 + \left(\frac{\theta_o + \theta_1 NEDC}{n} \right)} + \varepsilon_1, \qquad (6)$$

where θ's, τ, η and β_j's are to be estimated.

The market demand function (1) faced by retailers is assumed to take the double logarithmic form given by

$$\ln Q = \alpha_0 + \eta \ln(p_r / d) + \sum_{i=1}^{k} \alpha_i Z_i + \varepsilon_2, \qquad (7)$$

where $\ln$ indicates the natural logarithm operator, Q is the total quantity of fluid milk, d is a price deflator, Z_i denotes demand shifters, the α's and η are parameters to be estimated, and ε_2 is a random error.

To determine the impacts of private market power and the NEDC on the retail price, it is necessary to separate the two effects. One can decompose equation (6) into four scenarios shown in Table 2. Scenario A illustrates the actual situation with simultaneous distortions of private market power and the NEDC. Scenario B illustrates the impact of private market power on the retail price of fluid milk in the absence of the NEDC. Scenario C illustrates competitive retail pricing in the presence of the NEDC, the retail price being equal to marginal cost when the raw milk price is determined by the NEDC price floor. Scenario D illustrates the impact in the absence of private market power and the NEDC and represents the lowest hypothetical price paid by consumers.[6]

It is of particular interest to assess the retail price differential due to the NEDC in the presence of private market power, given by $\Delta P^{AB} = p_r^A - p_r^B$. It is also of interest to assess $\Delta P^{AC} = p_r^A - p_r^C$ to assess the price differential due to private market power in the presence of the NEDC. Last, $\Delta P^{AD} = p_r^A - p_r^D$ measures the simultaneous impact of NEDC and private market power. Obviously, the relevant policy change depends on a policy maker's degree of freedom in eliminating market imperfections and the strengths of special interest groups in the policy process.

To compare our results to previous studies of the effects of NEDC and to assess the impact of raw milk price policies on the retail price, the cost passthrough rate for milk ($CPTRM = \partial p_r / \partial p_f$) is computed as $CPTRM = \tau / [1 + (\theta_0 + \theta_1 NEDC) / \eta]$. We do not restrict the τ coefficient to any prior value (for instance, the common assumption of fixed proportion of one) in order to obtain a passthrough rate that is shaped by the data and the conjectural variation and demand elasticities. Note that Bailey's (2003, p. 120) results are based on a restricted proportional markup model given by the ratio of the retail price (or the forecast margin plus farm price) over the farm price, which, by definition, always yields a *CPTRM* greater than one. He reports a *CPTRM* of 1.83 (a 20.7-cent increase in the Boston retail price divided by a 11.3-cent increase in the raw milk price). Balagtas and Sumner (2003) assume *CPTRM* to be one.

4. Data and Estimation

Equations (6) and (7) are the basis for empirically assessing the market power of fluid milk retailers in the Boston market and the impact of the NEDC.

The model is estimated with data from the Boston milk market area. The core data came from the Information Resources Incorporated-Infoscan (IRI) database provided by the Food Marketing Policy Center at the University of Connecticut. It includes 58 four-week-ending observations covering the period from March 1996 to July 2000. The IRI data provided the values of fluid milk sales by each supermarket chain, the volume sold, and the percentages of fluid milk sold under promotion and price reductions. The retail milk price was computed by dividing total dollar sales by total volume.

The empirical measure of the raw milk price (p_f) is given by the Federal Milk Market Order (FMMO) announced Class I (fluid milk use) price or the announced Compact minimum price, whichever is higher. To the resulting price, the average over-order cooperative premium is added. Finally, the raw milk price is adjusted for butterfat sales extracted from an average gallon of milk sold in Boston to better reflect the true price the processor paid for raw fluid milk in the sample period.[7]

The retail marginal cost variable also includes non-milk input prices. These are: the average retail wage rate in the Boston area ($/hour) and a U.S. price index for packaging materials obtained from the website of the U.S. Bureau of Labor Statistics (2002); the Moody's bond rate for 10 years as an opportunity cost for variable capital inputs obtained from Economagic (2004); and the price of electricity for industrial use in Massachusetts obtained from the U.S. Department of Energy website (2004).[8] We also include the average volume per unit sold, available from IRI as a proxy for the amount of materials and added labor needed to supply a given volume of milk.

Shifters of demand include the percent of milk sold under sales promotion, the percent price reduction for promoted milk (through coupons or sales specials), and monthly aggregate consumer income in the Boston area. Both the retail price of milk and consumer income were deflated by the Boston consumer price index. At this level of analysis using scanner data, no obvious substitutes or complements for fluid milk were apparent.[9]

For the counterfactual experiments, note that raw milk prices for scenarios A and C (Compact with and without private market power) and for B and D (no Compact with and without private market power) are the same in the pre-Compact period. For scenarios A and C, the raw milk price used is the same as in the econometric estimation.

Note that the Boston class I price is set by national Federal guidelines independently of the Compact. Thus, for scenarios B and D analyzing prices in the absence of the Compact, the raw milk price is assumed to follow the actual Boston class I price plus an estimated coop premium[10] plus an adjustment for butterfat. The actual coop premia is used in the adjustment for the few observations where the class I price was so high anyway that it was above the Compact floor. The estimated average impact of the Compact on raw milk prices is 9 cents per gallon in the post-Compact period.

The system of equations in (4) and (5) is recursive, nonlinear in parameters, and has a cross-parameter restriction (η). Given the potential endogeneity of the retail milk price in the demand equation, the weighted average of the retail milk prices in Providence, Rhode Island, and Hartford, Connecticut, was used as an instrumental variable in lieu of the Boston retail price. Then, the system of equations was estimated using the Seemingly Unrelated Regressions technique. The results are presented in the following section.

5. Empirical Results

Estimated Parameters

The parameter estimates for equations (6) and (7) are summarized in Table 3. All results appear reasonable and conform to *a priori* expectations.

The empirical results indicate that the conjectural variation elasticity estimate either before $(\hat{\theta}_0 = 0.1409)$ or after the Compact $(\hat{\theta}_0 + \hat{\theta}_1 = 0.1592)$ is significantly different from zero at the 5% level. This means that market conduct is not perfectly competitive. On the other hand, the hypothesis of perfect collusion ($\theta_0 = \theta_0 + \theta_1 = 1$) was also rejected at the 5% level, meaning that retailers are not perfectly collusive either. In addition, the Cournot hypothesis $\theta = \theta_0 + \theta_1 = 0.1663$ (the average Herfindahl index for retail milk sales in Boston during the sample period) was also rejected at the 5% level. In fact, a one-sided test shows that conduct is more collusive than Cournot behavior; thus, supermarkets do not ignore each other's actions.[11]

Note that the incremental collusion term after the institution of NEDC (θ_1) is positive and significantly different from zero at the 5% level. Its magnitude suggests that the NEDC did have a discernable effect on the conjectural variation elasticity and that the NEDC event may have served in part as a focal point for increasing tacit coordination of prices.

The pre- and post-NEDC Lerner indexes (0.2309 and 0.2609) are also significantly different from zero at the 5% level. The value of the Lerner index suggests that retailers do exert a significant degree of oligopoly power by setting fluid milk retail prices above the level dictated by competitive pricing. The markup over the marginal cost, which serves as the competitive benchmark, is approximately one-quarter of the retail milk price, although percent markups changed little with the Compact. The retail dollar markup before the Compact was estimated at \$0.6775 and after the Compact at \$0.7658 – an 8.83 cent increase. Given that the retail milk price averaged \$2.93 per gallon during the 1996-2000 period, these imply very substantial profit margins.

The marginal retail-level cost estimates average approximately \$2.21/gallon for the sample period. From an average adjusted raw milk price of approximately \$1.33, this amounts to an estimate of \$0.88/gallon for processing and retailing cost on average. The cost-engineering estimate put forward by Cotterill (2003) is around \$1/gallon by adding estimates from separate cost engineering studies by Durling and Szot (2003) for processing milk in Southern New England (\$0.60/gallon) and Criner (2003) for retailing it in Maine (\$0.42/gallon). After correcting for inflation (11% between the June 1998 midpoint and 2003), our estimate is quite consistent with these estimates.

The empirical results further show that the price elasticity of demand for milk at the retail level in Boston is estimated at approximately -0.6102, illustrating that fluid milk demand in supermarkets is inelastic, consistent with elasticity estimates presented by Johnson, Stonehouse and Hassan (1992).[12] The inelastic nature of consumer demand also corroborates the potential for the further exercise of oligopoly power if current consolidation trends in processing and retailing continue. The coefficient for consumer income is negative although not statistically significant at the 5% level. Nonetheless, a negative sign for the income elasticity of fluid milk demand is not out of the questions in studies of consumer panels (Huang, 1985 Blaylock and Smallwood, 1983).

Impacts of NEDC vs. Private Market Power

The relative impact of the NEDC on retail milk prices is determined two ways: the passthrough rate from farm to consumer price and the simulation of counterfactual experiments in Table 2.

The *CPTRM* for milk is estimated at 0.6758 after the implementation of the NEDC. This means that approximately 68% of the changes in the raw milk price are reflected in the final price paid by consumers, *ceteris paribus*. This price transmission estimate is comparable to the one found by Lass et al. (2001).[13] This finding helps explain the opposition of processors and retailers to policies that increase the raw milk price: as raw milk prices increase, they are only able to pass on part of the price increase, thus absorbing nearly 32% of the price increase. The partial passthrough also helps explain the rent seeking activities by milk intermediaries who supported the new milk price subsidy program that lowers farm level milk prices since channel firms are able to retain 32% of the cost savings, thus increasing retail margins.

The estimated passthrough rate of 0.6758 is in sharp contrast to analyses used to defeat the NEDC. For instance, a passthrough of approximately 1.83 proposed by Bailey (2003) and the agribusiness lobby under a fixed proportional markup is approximately three times higher than the one estimated in this study. Bailey's estimate implies, for instance, that milk retail prices should have dropped by nearly 90 cents per gallon after the 50-cent decrease in the raw milk price in December 2001, which clearly did not happen.

On this point Kilman (2003) notes that the national (rather than Boston's) milk farm price plunge (35% between September 2001 and June 2003) was not been fully passed on to consumers (9% drop in the same period). Cotterill (2003) provides some compelling data for March 2003: On average, New England farmers were paid $1.03/gallon, milk processors received $1.63/gallon and supermarkets charged consumers $3.10/gallon. A 50-cent drop in the raw milk price to $1.03 translated into only a 10-cent decline in the consumer price and retail margins amounted to $1.47 of the $3.10 price. Without controlling for other factors that affect processing and retailing costs, these numbers imply a passthrough between 0.20 and 0.26.

Figure 2 shows the resultant retail prices for fluid milk in Boston under our four scenarios. The gaps represent overcharges attributed to retail oligopoly, the NEDC or both. Of course, the pre-Compact scenarios for A and B, and C and D are the same. Therefore, only retail prices and their differentials during the Compact period are compared (40 observations from July 1997 through July 2000 in the sample).

The average retail price under scenario A (private market power and NEDC) in the Compact period is approximately $3.055/gallon and under scenario B (retail oligopoly power without NEDC) is $2.904. Thus, the average increase in the retail price due to the NEDC in the presence of retail oligopoly power (ΔP^{AB}) is approximately $0.151/gallon. This estimate includes both the pure price transmission as well as the increase in collusion brought about by the Compact.[14] On the other hand, the average retail price under scenario C (perfect competition and NEDC) is $2.280/gallon. Thus, in the presence of the NEDC, the average increase in the retail price due to oligopoly markup (ΔP^{AC}) is approximately $0.775/gallon. The average retail price under scenario D (perfect competition and no NEDC) is $2.234/gallon. Thus, if the retail sector were competitive, the average increase in the consumer milk price due to the NEDC would have been 4.6 cents, precisely the increase in the raw milk price.[15]

Although the NEDC had a significant impact on retail prices and captured most of the media, political and academic attention, the impact of private market power far outweighed the impact of the NEDC. In fact, that impact is over seven times the size of the NEDC impact.[16]

6. Concluding Remarks

The findings reported in this article strongly support the notion that supra-normal milk prices in Boston during the Dairy Compact era were mostly due to the exercise of significant private market power and not to the exercise of price enhancement via the NEDC. In fact, they reveal that retail price increases due to private market power outweighed those caused by the Northeast Dairy Compact by nearly 7 times. Oligopoly markups are estimated at approximately 25% of the retail milk price, translating into an approximately $0.75/gallon overcharge when retail prices averaged a little under $3/gallon. The estimated passthrough rate sheds light on the lack of response of retail prices to raw milk prices and provides a rationale for rent seeking activities by channel firms in support for public policies that lower the acquisition price of raw milk.

Ultimately, the findings of this study illustrate that inclusion of market power by intermediaries should be considered when designing a dairy policy program. Assuming that market channels are perfectly competitive or that intermediaries simply use a fixed proportional markup pricing rule can lead to deceptive equity and efficiency policy conclusions regarding programs that purport to assist dairy farmers and help consumers. Indeed, the new Milk Income Loss program has helped smaller dairy farmers and benefited consumers. This study suggests that it also produced substantial large benefits to retailers in Boston and other areas of the country where retail market power may be high. All these benefits, however, have come at the expense of the taxpayer. In this regard, further research on the distribution of program benefits in the context of a non-competitive market channel would be extremely useful. This line of inquiry, nonetheless, is beyond the scope of this article.

Footnotes

1 In July 1997, the NEDC was created with the presumption that it would have several desirable social benefits, including providing more stable farm prices without the infusion of federal tax dollars. Critics raised major questions concerning the impact of the Compact on consumers (i.e., the retail price of fluid milk), the potential spillover price effects to producers in other regions, and the effects on processors and retailers (Bailey, 2001).

2 For a general discussion of this emerging problem in a different industry (electric utilities), see Borenstein and Holland (2003).

3 This 3 ½ year program provides a federal payment to producers each month equal to 45% of the difference between $16.94 and the Boston Class I price. Payments are made on up to 2.4 million pounds of production per year to a producer anywhere in the U.S. This program started in the summer 2002 with a budget of $1 billion but has cost over $4.8 billion due to record low farm milk prices nationwide.

4. Dean Foods processes many brands including Garelick, Sealtest, and the private label brands of nearly all supermarkets and Wal-Mart in the Boston area. During the period of analysis, Stop and Shop --the leading retailer in Boston—was vertically integrated into processing not only its own private-label milk but also Hood milk (under licensing), which is the leading manufacturer brand. Since then it is operating under a 20-year contract with Dean Foods. Either through contractual processing which affects the bulk of fluid milk in the Boston area, or though vertical integration, we abstract from questions regarding any market power in the market channel other than retailers' oligopoly power. Several studies also point out the weak oligopoly power of milk processors (Suzuki et al., 1994; Liu et al., 1995) or weak price effects of processor concentration (Lopez et al., 2002).

5. An exception is Seattle where most milk processing and retailing is vertically integrated via Safeway and Kroger supermarkets. In fact, Seattle has been shown to have the highest retail price for milk in the country (Carman and Sexton, 2004).

6. The two scenarios for "perfect competition" in raw milk pricing (scenarios C and D) refer to a situation where the price of raw milk is determined by Federal regulation (class I) rather than under a "free market." A true free market price would involve dismantling of Federal involvement, including barriers to international trade. Thus, in a sense, scenario D represents a second-best situation taking Federal price regulation as exogenous to the model.

7. Although we are interested only in fluid milk as the output of milk processing, milk butterfat is a byproduct also sold by processors. Thus, to reflect the effective raw milk price paid by processors, a "net price" of raw milk is obtained by subtracting byproduct credits from the price of butterfat. An alternative specification used in the literature defines the raw milk price as milk with 3.5% fat content. This definition, however, ignores the important butterfat sales if one is considering fluid milk. On average, butterfat credits amounted to approximately 20 cents per gallon of raw milk (13% of the 3.5% fat price) in the period of analysis. However, using this alternative definition did not change the results by much as marginal costs and margins turned

out to be very close after posterior adjustment for butterfat credit. Thus, the results were robust with respect to the milk price specification and they are available from the authors upon request.

8. As pointed out by Criner (2003), following an accounting approach for four Maine supermarkets, milk retailing costs include both direct and indirect costs. First and foremost, direct costs consist of the acquisition price of bottled milk as well as labor and electricity. Indirect costs consist of overhead for equipment, salary and retail space. Since we are concerned with the marginal cost, rather than the unit total cost, we do not consider explicitly unassigned fixed costs. At the processing level, Durling and Szot (2003) include the acquisition price of milk, packaging and labor as the determinants of the direct cost of milk processing while making allowances for overhead charges for administration, marketing and insurance. Dalton, Criner, and Halloran (2002) attribute most milk cost to "supplies" (including packaging and milk) and labor. One should also keep in mind that we flush out the marginal cost values via econometrics rather than accounting estimation. We attempt to capture marginal retailing cost by including labor and energy cost plus the implicit wholesale price charged by processors who deliver the milk to the display site in the supermarket. We include the Moody's bond rate to partially capture the variable cost of capital services attached to overhead, including retail space, and a marginal cost intercept to allow for other factors not attributable to the included input costs.

9. Previous studies on milk using scanner data (e.g., Cotterill and Dhar, 2003); Kinoshita et al, 2001) typically consider only substitution across brands of milk. Since we have aggregated all brands and consider the average price of milk, this possibility is not relevant. In addition, several attempts to include the price of orange juice worsened the statistical results without providing any additional insight. For completeness, we included the monthly consumer income for Boston extrapolated from quarterly data. However, the paucity of the data and the short time span (less than five years) of the sample preclude us from estimating a traditional model of demand typical of longer time series of annual data.

10. Over-order payment is a payment above the Federal order minimum prices negotiated between buyers and sellers to cover cost of providing market services or attracting adequate milk supplies. They can take the form of coop premia or be the result of regulation such as dairy Compacts. In the absence of regulation, over-order coop premia (*CP*) are negatively correlated with class I prices (P1) as milk cooperatives would require less compensation when class I prices are high. Using the 19 observations before the Compact, the following OLS regression was used to estimate the would-be coop premia for periods when the Compact was effective:

$$CP_t = 1.2763 - 1.6239P1_t + 0.5441\ P1_t^2,$$
$$(2.847) \quad (2.538) \qquad (2.393)$$

where the values in parentheses are the absolute values of the t-statistics, the R^2 =0.566, and N=19. For the periods when the Compact was in place but not effective (prices above the price floor of $1.46/gallon for 3.5% butterfat milk), the actual premia were used.

11. An alternative testing for Cournot model was conducted via a J-test since, unlike the competitive conduct, that model is non-nested for variables levels of the Herfindahl index. The MacKinnon et al. (1983) J-test was used to test the unrestricted θ model versus Cournot conduct. The pricing relationship tested was:

$$p_r = (1-\alpha)\left(\frac{\tau\, p_f + \beta_0 + \sum_{i=1}^{n+m} \beta_i W_i}{1+\left(\frac{\theta_o + \theta_1 NEDC}{\eta}\right)}\right) + \alpha\left(\frac{\tau\, p_f + \beta_0 + \sum_{i=1}^{n+m} \beta_i W_i}{1+\left(\frac{H}{\eta}\right)}\right) + \varepsilon_1,$$

where H is the milk retail Herfindahl index. The value of α for the Cournot case is estimated at –0.0351 and its t-ratio was estimated at –1.20025. Thus, the Cournot conduct. Assumption does not add any significant information over the unrestricted model. Hence, one reject the Cournot model specification in favor of the unrestricted model presented in Table 3.

12. This estimate is not as inelastic as is commonly found in consumer panel studies (e.g., -0.2588 by Huang, 1985). However, it is lower than those found at the individual supermarket level (e.g., -2.6 in Cotterill and Dhar, 2003; -1.47 to –5.0 in Kinoshita et al., 2001).

13. Converting the estimates of *CPRTM* in Table 3 to mean elasticities (by multiplying them by the mean of p_f / p_r), the transmission elasticities are estimated at 0.3311 before the Compact and 0.2911 after the Compact (cf. 0.35 in the study of Lass et al (2001)).

14. In comparison, Bailey (2003) concluded that the NEDC's impact was much higher at 20.7 cents per gallon. Dhar (2001) found price increases ranging from 7 to 17 cents for different brands of milk at the supermarket level in the Boston area. Lass et al. (2001) found an average effect of the Compact on Boston retail prices of 6.9 cents per gallon. Thus, the magnitude of the price increase found in this paper (15.1 cents) is in the range of those in previous studies.

15. For the full sample (58 observations) including the pre-Compact period, the average prices were as follows: \$2.948 for scenario A, \$2.831 for B, \$2.209 for C, and \$2.177 for D.

16. For a more recent evaluation of the impact of public vs. private market power in New England milk market channels see Cotterill (2003) where a 10:1 ratio of private to public price enhancement in these channels is reported.

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Table 1: Characteristics of the Milk Retailers in Boston

Characteristic	Stop & Shop	Shaw's	DeMoulas	Star Market	Others
Milk Market Share (%)	27.04	20.50	18.44	12.71	21.31
Grocery Market Share	30.67	16.75	12.52	13.58	26.48
In-Store Private Label Milk Share (%)	68.07	68.78	87.48	48.94	na
Average Store Square Footage (1000)	83.44	40.90	40.59	38.18	20.99

Source: IRI and Market Scope (Trade Dimensions), 1996-2000.

Table 2. Retail Prices under Alternative Scenarios

	NEDC	No NEDC
Oligopoly	A: $p_r^{A} = \dfrac{\tau p_f + NMMC}{1 + \dfrac{(\theta_0 + \theta_1 NEDC)}{\eta}}$	B: $p_r^{B} = \dfrac{\tau p_f^{*} + NMMC}{1 + \dfrac{\theta_0}{\eta}}$
Perfect Comp.	C: $p_r^{C} = \tau p_f + NMMC$	D: $p_r^{D} = \tau p_f^{*} + NMMC$

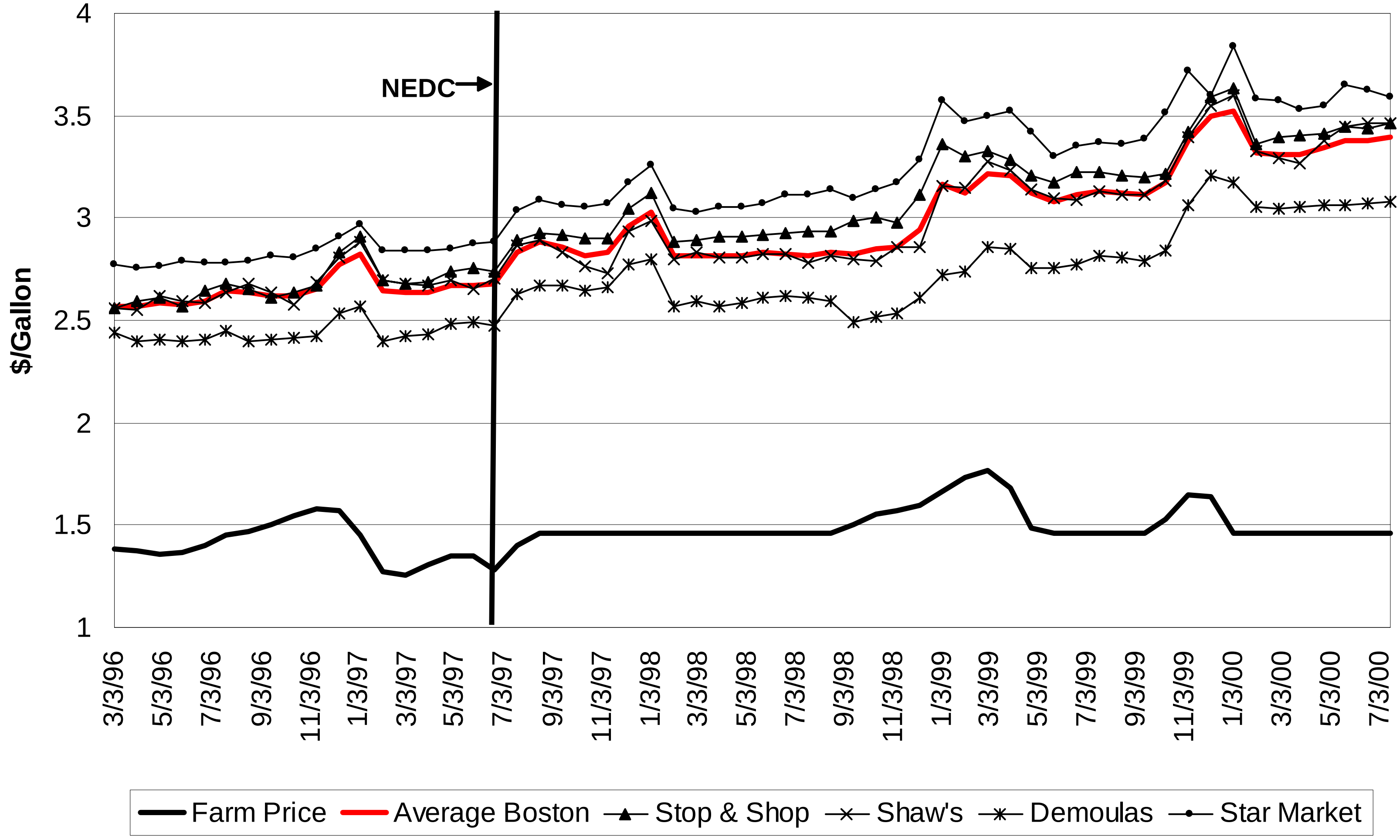
Notes: p_f^{*} represents the farm level price in the absence of the NEDC, $NMMC = \beta_0 + \sum_{i=1}^{n+m} \beta_i \overline{W_i}$ is the non-milk marginal cost.

Table 3. Parameter Estimates for Retail Pricing and Demand in the Boston Milk Market.

Variable	Parameter(s)	Estimate	T-ratio
Pricing Equation			
Pre-NEDC Conj Var. El	θ_0	0.1409***	2.5201
NEDC Dummy	θ_1	0.0184***	2.3896
Post-NEDC Conj. Var. El.	$\theta_0 + \theta_1$	0.1592***	2.5467
Raw Milk Price	τ	0.4995***	7.0176
MC Constant	β_0	-2.8376***	2.4885
Retail Wage Rate	β_1	0.2131***	12.1280
Packaging Price Index	β_2	0.0086*	1.5468
Electricity Price	β_3	0.0189	1.4332
Interest Rate	β_4	0.0344	1.4437
Volume per Unit	β_5	-0.0109	0.0888
Marginal Cost	$\tau \overline{p}_f + NMMC$	2.2096***	412.2374
Price Elasticity of Demand	η	-0.6102***	2.5397
Demand Equation			
Constant	α_0	18.0620	4.6849
Retail Price	η	-0.6102***	2.5397
Percent Promotion	α_1	0.0021*	1.8559
Percent Price Reduction	α_2	0.0052*	1.7322
Income	α_3	-0.1035	0.6463
Related Measures			
Pre-NEDC:			
Lerner Index	$-\theta_0 / \eta$	0.2309***	58.0367
Dollar Markup	$(-\theta_0 / \eta)\,\overline{p_r}$	0.6775***	58.0337
Price Transmission	$\beta_1 /(1+\theta_0 / \eta)$	0.6494***	7.1072
Post-NEDC:			
Lerner Index	$-(\theta_0 + \theta_1)/\eta$	0.2609***	102.3701
Dollar Markup	$(-(\theta_0 + \theta_1)/\eta)\,\overline{p_r}$	0.7658***	102.3701
Price Transmission	$\beta_1 /(1+(\theta_0 + \theta_1)/\eta)$	0.6758***	4.0063

Notes: Two and three asterisks indicate significance at the 5 and 1 percent levels, respectively. N=58 four-weekly observations between March 1996 and July 2000. T-statistics are in absolute value and are calculated relative to the null hypothesis that the parameter is zero. Non-milk marginal cost is defined by $NMMC = \beta_0 + \sum_{i=1}^{n+m} \beta_i \overline{W_i}$.

Figure 1. Farm and Retail Milk Prices at the Top Four Supermarkets in Boston, March 1996 through July 2000



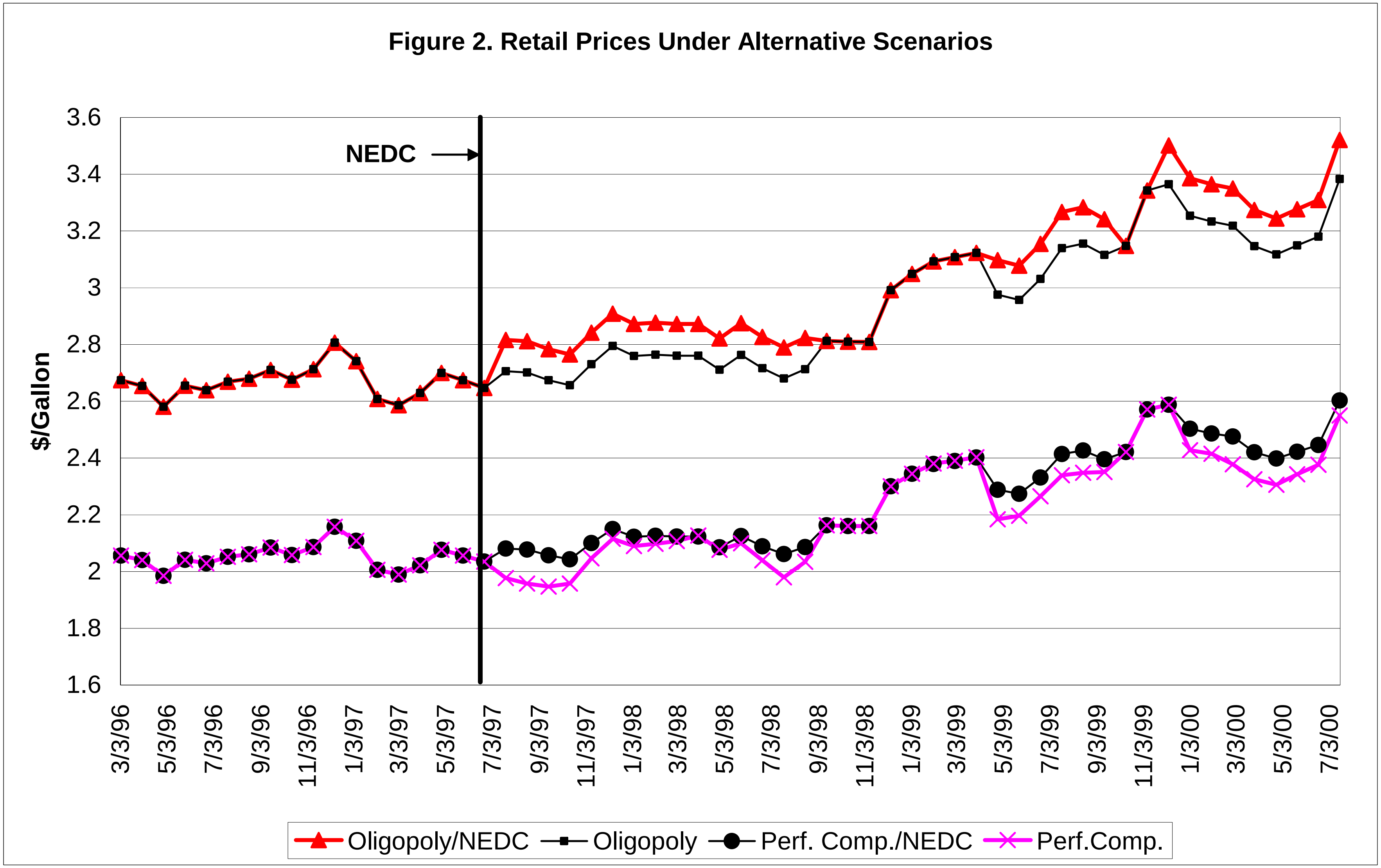


Figure 2. Retail Prices Under Alternative Scenarios
NEDC
$/Gallon
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
3/3/96
5/3/96
7/3/96
9/3/96
11/3/96
1/3/97
3/3/97
5/3/97
7/3/97
9/3/97
11/3/97
1/3/98
3/3/98
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11/3/98
1/3/99
3/3/99
5/3/99
7/3/99
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11/3/99
1/3/00
3/3/00
5/3/00
7/3/00
Oligopoly/NEDC
Oligopoly
Perf. Comp./NEDC
Perf.Comp.

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