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LIMIT PRICING IN THE NITROGEN FERTILIZER MARKET: AN APPLICATION TO THE SASKATCHEWAN MARKET

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1. Introduction

Canadian farmers have a long history of concern over monopoly market structures. The most apparent and often accused sectors are the railways and the private grain companies, however, farmers have expressed their concern over other input markets such as fuel oil, farm machinery and fertilizers. The Canadian government has taken these concerns seriously in the past as evidenced by the Royal Commission on the Farm Machinery Industry in 1965, the regulation of freight rates in the railway system, and more recently, the Saskatchewan Government hearings on the cost of farm inputs. The cooperative movement in Western Canada resulted in large part because of the monopoly conditions facing farmers. Cooperatives were a form of business enterprise that competed with local monopolies to provide rural people with services at reasonable costs.

The issue of monopoly has never been examined in the agricultural economics literature in Canada. All the debate on transportation issues in Western Canada never resulted in any studies to examine if the railways were pricing competitively, or if there was some monopoly profit in the system. The same comment holds for farm inputs such as fertilizer and herbicides.

The question of industrial structure or organization is an important and growing field of applied economics. It is equally important for agricultural economics because of the competitive nature of farming. If farmers, who are in a competitive industry, must purchase input supplies from a non-competitive industry, then farmers will pay too much for inputs because they have no bargaining power.

This paper provides an answer to the farmers question regarding the nitrogen fertilizer market in Western Canada. We recognize that our results are not as complete as we would like because of the data, however, they do provide some insights to the structure of the Western Canadian fertilizer industry.

The first part of this paper provides some historical background to the structure of nitrogen fertilizer industry in Western Canada since 1930s, and to nitrogen use in Saskatchewan agriculture in the last two decades. The second and third parts discuss the limit-pricing model and its empirical application to the Western Canadian fertilizer industry. Although the limit-pricing model is discussed extensively in industrial organization literature, the empirical applications of the model are rather limited. The empirical application set out in this paper is a contribution to the industrial organization literature with respect to the agricultural sector the economy.

2. Historical Background

The Canadian nitrogen fertilizer industry has experienced a rapid growth since 1969 yet there is a noticeable lack of entry by new firms since that date. The Canadian nitrogen industry was started in 1931 with the commencing of production by Cominco Ltd. Between 1931-1954 Cominco was the only nitrogen fertilizer producer in Canada. In 1954 Sherritt Gordon started producing nitrogen fertilizers, and was followed by Western Cooperative Fertilizers Ltd. in 1964, Simplot Ltd.

in 1967, and Imperial Oil in 1969. Since 1969, these established firms have expanded their capacities but no new firms have entered the industry.

The major plants are located in Alberta because of the abundance of low cost natural gas, which is the primary feed stock of industry. One plant is located in southern British Columbia, and Simplot is located in Brandon, Manitoba. No plants exist in Saskatchewan despite the fact that Saskatchewan is a major growing fertilizer market.

The demand for nitrogen fertilizer by farmers is a derived demand. The quantity of nitrogen used by Saskatchewan farmers has increased significantly (approximately eightfold) in the past fifteen years (see Table 1). This incease in use has occurred in part because of, (i) increased farmer awareness of the benefits of nitrogen, (ii) the depletion of nitrogen available in the soil, (iii) continuous cropping, (iv) the relaxation of Canadian Wheat Board delivery quota's, and (v) the introduction of the Crop Insurance program which reduced the risk of natural hazards.

In response to the increased demand for nitrogen, the five firms have expanded production, mainly anhydrous ammonia, but no new firms have entered the industry. In Western Canada, established anhydrous ammonia capacity has expanded from 2,156,400 tonnes per year in 1978 to 3,118,026 tonnes per year in 1985.[1] The industry has always been in a state of overcapacity because plant expansion exceeded domestic market growth. The recent expansion in the capacity of firms in Western Canada has resulted in an increase in the volume of Canadian

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[1] Blue, Johnson and Associates, August, 1985.

exports of anhydrous ammonia and urea. The export of urea in the 1983/84 fertilizer year (July 1 to June 30) of 686,622 tonnes increased to 1,239,890 tonnes in 1984/85.[2]

The current price spread between off shore nitrogen (anhydrous ammonia) and domestically produced nitrogen is more than can be explained by transportation and handling charges. The price of nitrogen (on actual N basis) in 1985 is approximately US $171.00/tonne at the Gulf (CDN $234.00) compared to CDN $500.00/tonne on farm price in Saskatchewan. Unfortunately, there is no wholesale price series available in Canada for a meaningful comparison. The only price indicator is in the farm input price index for the groups of fertilizers and mixed fertilizers. This is an index and does not represent either N or P contents individually or in a fixed proportion.[3] The only available price series is obtained by using export statistics. The volume and value of exports of fertilizers by type is reported by Statistics Canada. From these figures, one can calculate the price of nitrogen fertilizers moving to the export markets (see Table 2).

The lowest price for nitrogen in North America is at the Gulf Coast. The U.S. price rises as one moves from the Gulf Coast to the Pacific Northwest.[4] The prices in Montana and North Dakota are

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[2] Statistics Canada, 46-504.

[3] H.F. Carman points out the same problem in the U.S.A. He uses the nitrogen price index which is based on the price of ammonia sulphate since the price of ammonia sulphate was the only price series available. Western Journal of Agricultural Economics, July 1979, p. 25.

[4] Blue, Johnson and Associates, August, 1985, p. 41.

similar to those in Nebraska and Oklahoma. The price of nitrogen in Canada is substantially higher than those in Montana and North Dakota. The puzzle is why should Canadian prices be higher than those in Montana and North Dakota, when Canadian firms export to these markets.

A brief review of history indicates that the Western Canadian fertilizer industry was charged under the Combines Investigation Act that, during the period between the 1st of January, 1965, and the 16th of January, 1976, its members did unlawfully conspire, combine, agree or arrange together and with one another to prevent or lessen unduly competition in the production, manufacture, purchase, barter, sale and transportation of fertilizers within Western Canada.[5] The charges were against the manufacturers of fertilizers as well as a number of distributors. During the trial only limited evidence was provided by the Crown regarding the way in which the prices of nitrogen was set. It was suggested by one economist that the nitrogen industry in Western Canada was of an oligopolistic nature, however, the oligopolistic structure of the industry does not necessarily imply that the manufacturers are fixing the prices of nitrogen fertilizers to Western Canadian farmers. The result, after a lengthy hearing, was a judgement in early 1980 which produced a verdict of "not guilty" and an adjournment of the case.

The question remains as to what the pricing strategy of a firm is with respect to the nitrogen market. All our evidence suggests that the established firms adopt a strategy to restrict entry of new firms,

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[5] Paraphrase of the charge as recorded in the court proceedings of the Supreme Court of Alberta, Calgary. <u>Crown Versus Cominco, et al.</u>, 1980.

rather than to fix prices. Nitrogen fertilizers can be considered a homogeneous product in which case strategies like massive advertising or brand proliferation to deter the entry would not be operational.

3. The Limit-Pricing Model

The industry appears to be characterized by limited entry to a market that has experienced substantial growth. The limit-pricing model employed in this paper is based on a paper by Franco Modigliani[6] which has been formalized by Anna Koutsoyiannis.[7] The limit-pricing model depicts how firms in an industry can limit entry so as to obtain above normal profits.

The model is based on the assumption that the industry's long-run average cost curve is L-shaped, that is to say, cost of production reaches its minimum at a certain level of output and does not change thereafter. That level of output at which the economies of scale are fully realized is referred to as minimum efficient scale (MES), and MES constitutes a significant portion of market size. Entry occurs with the minimum efficient plant size, at a scale smaller than MES, costs are prohibitively high to enter the industry. It is implicitly assumed that entry comes from new firms.

The product is assumed to be homogenous and the market demand is known. Given the long-run average cost and market demand curves are known, the limit price can be determined.

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[6] Franco Modigliani, "New Developments in Oligopoly Front", JPE, 1958.

[7] Anna Koutsoyiannis, Modern Microeconomics. MacMillan Press, 1979.

The established firms set the entry-deterring price indirectly by determining the total output which will be sold by all firms in the market. The entry-preventing level of output, X_L, is determined such that if entry occurs with a plant size equal to or larger than MES, the total output in the market will just exceed the competitive output, X_C, and the price will fall just below the competitive price, P_C (see Figure 1).

The basic postulate underlying this model is that the established firms believe that the new entrant cannot enter with a plant size smaller than MES, and they will not enter if they believe that post-entry price will fall below P_C. The new entrant expects that the existing firms will keep their output constant at the pre-entry level and will not reduce their own market share to accommodate the new entrant. Therefore, entry will be prevented as long as $(X_L + MES) \geq X_C$ and limit price, P_L, is set accordingly.

The difference between limit price and competitive price, (P_L - P_C) is the entry gap or the maximum premium that oligopolists can command above the long-run average cost without attracting entry.

The determinants of entry gap and the limit price are;

(a) the absolute market size, X_C,

(b) the price elasticity of demand, μ ,

(c) the minimum efficient scale, (MES),

(d) the long-run average cost, P_C, which is determined by the prices of the factors of production and the state of technology.

These factors can be combined in the following formula:

$$P_L = P_C \left[1 + \frac{(MES)}{X_C \cdot |\mu|}\right]$$ [8]

The limit price, P_L, is positively correlated with minimum efficient scale and long-run average cost, and negatively correlated with the market size and the price elasticity of demand. The higher the proportion of MES to absolute market size, the larger will be the entry gap. Hence, in order for this strategy to be effective, MES needs to be a non-negligible portion of the market.

4. The Empirical Estimation

The model presented in Section 3 is dependent upon two behavioral relationships; market demand curve, and the long-run average cost curve. This is not a simultaneous system in the sense of normal supply and demand, rather the limit price is determined once we know the average cost of production or P_C; market size, X_C; and μ.

In our model, the fertilizer market refers to the Saskatchewan market. There are basically two reasons for treating Saskatchewan as a separate market. Firstly, fertilizer distributors are organized on provincial basis. The Western Canadian fertilizer distribution network does not provide a visible wholesale price f.o.b. the manufacturing plant, but rather, each dealer receives the product at a landed price at his location.[9] This kind of pricing arrangement makes

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[8] For the derivation of this expression, see Modern Microeconomics, p. 315.

[9] This observation is made after discussion with industry experts, including fertilizer dealers and is consistent with the statement that "the price structure for fertilizer in Western Canada is principally on a delivered rather than on an f.o.b. basis..." (Blue, Johnson and Associates, August, 1985, p. 4).

it easier for the large manufacturing companies to maintain price discipline within various regions across Western Canada. Secondly, the crop mixes and amounts of summerfallow are different across the provinces, and the tax laws for natural gas are on a provincial basis. These would give rise to different demand elasticities for fertilizers across the Western Canadian provinces. Unfortunately, demand elasticity for fertilizers is not available for other provinces to substantiate this point.

The demand for nitrogen fertilizers in Saskatchewan has been estimated by D.B. Anderson. He reported an estimate of μ as (-0.6).[10] R.D. Lopez, by using the duality theory, estimated the price elasticity of demand for intermediate inputs in Canada to be (-0.4).[11] As these were the only studies the authors could locate on the demand for nitrogen fertilizer, we took $\mu = -0.6$ as the most reasonable estimate for Saskatchewan.

The average cost curve was estimated by using pooled cross-sectional and time series data. Data was available from Blue, Johnson and Associates on the average total cost of production for 11 nitrogen fertilizer plants located in Western Canada over the period 1978-85 (total 76 observations).

A test of the hypothesis that long-run average cost curve of the industry is L shaped and the MES is equal to 99,791 tonnes of actual N

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10 Anderson, D.B. "Demand Analysis for Nitrogen Fertilizers in Saskatchewan," unpublished B.S.A. thesis, Dept. of Agricultural Economics, University of Saskatchewan, Saskatoon, 1984.

11 Lopez, R.D. "The Structure of Production and the Derived Demand for Inputs in Canadian Agriculture," AJAE, 1980.

per year was performed. The volume of MES comes from engineering studies, and is commonly available to and used by the nitrogen fertilizer industry.

The cost model was specified as:

$$AC_t = b_o + b_1 C_t + b_2 (C_t - MES) D_t + e_t$$

where

AC_t = average cost of production deflated by natural gas price index (1985 = 100)

C_t = plant capacity

MES = as defined previously and assumed to be constant over the period in question

e_t = disturbance term and $e_t \sim N(0,\sigma^2)$

$$D_t = \begin{cases} 1 \text{ for } C_t > MES \text{ (45 observations)} \\ 0 \text{ for } C_t \leq MES \text{ (31 observations)} \end{cases}$$

Dummy variable, D_t, is used to divide the sample into two groups in accordance with plant size as those greater and smaller than MES.

The slope coefficient b_1 is expected to have a negative sign and $b_1 + b_2 = 0$. If $b_1 + b_2 = 0$, then the slope of the cost curve beyond MES is zero.

The estimated equation for the cost curve is

$$AC_t = \underset{(6.3)}{446.5} - \underset{(-2.9)}{2.16}\, C_t + \underset{(2.5)}{2.13}\, (C_t - MES)D_t; \quad F_{2,73} = 5.2$$

The numbers in brackets are t-statistics, and indicate that at $\alpha = 0.05$ all estimated coefficients are significantly different from zero. F-ratio exceeds the critical value ($F^c = 3.13$) at 95 percent significance level and indicates that the overall model is significant as well.

This equation can also be read as two equations:

$AC_t = 446.5 - 2.16\ C_t$ for $C_t \leq MES$

$AC_t = 233.9 - 0.03\ C_t$ for $C_t > MES$

The equation for $C_t > MES$ gives us the estimated average cost or P_c equal to $234/tonne of N. It is worth notting that this estimated price is exactly the same as wholesale price of nitrogen at the U.S. Gulf Coast (see p. 4).

The hypothesis that the slope coefficient of the average cost curve for $C_t > MES$ is significantly different from zero was also tested. The hypothesis was rejected. We then proceeded with the notion that the long-run average cost curve for nitrogen fertilizer industry is "L" shaped, and MES = 99,971 tonnes of N per year.

Another estimate of the AC was obtained from the financial statements reported in the annual reports of Cominco Ltd. Cominco Ltd., at its Carseland Plant in Alberta, produces anhydrous ammonia and urea. The difference between total revenue and operating profits generated in this plant was used as a proxy for the total cost of production. Total output was computed in terms of urea and the conversion was made on the basis of 46/82 ratio between urea and anhydrous ammonia. The total cost of production was modified such that the additional cost of transforming ammonia to urea ($40 per tonne of urea) was included and assumed to remain constant over the time period 1980-84. The computed average cost of production using this method was $220 per tonne of nitrogen.

The limit prices calculated on the basis of these computed and estimated average costs of production are given in the Table 3. The limit prices were calculated on the assumption that the quantity of nitrogen fertilizers consumed in Saskatchewan in 1985 represents the entry-deterring level of output, X_L, in the market, and that the sum of X_L and MES is equal to the competitive level of output, X_C.

The limit price computed on Table 3 ranges between $344 per tonne and $431 per tonne of N depending on the competitive price, and price elasticity of demand chosen in calculations. We would pick $365 per tonne of N as the best estimate for two reasons. Firstly, the data used in estimation equation is much richer than the data used to compute P_C = $220 per tonne of N. Secondly, the price elasticity of demand estimated by Lopez (-0.4) is for all intermediate inputs in Canadian agriculture and possibly understates the price elasticity of demand for nitrogen fertilizers in Saskatchewan. Given that P_C = $234 per tonne of N and $\mu = -0.6$, the limit price is coincident with the price of $365 per tonne of N that five established firms charge their fertilizer distributors. This price is approximately 60 percent over the estimated average total cost of production, and this premium is captured by these firms with no danger of entry by potential entrants.

Canadian firms have exported anhydrous ammonia to the U.S. market for $221.55 per tonne[12] of nitrogen in 1985 while the wholesale price, or the limit price, of the same product in Saskatchewan was $365 per tonne of nitrogen. This situation raises the question why there is no arbitrage occurring between two markets in such a way to reduce the prices in Saskatchewan. Currently, there is no anhydrous ammonia movement between Saskatchewan and the U.S., however, we requested the Potash Corporation of Saskatchewan to provide us an estimate of

[12] f.o.b. price, Statistics Canada, 65-202.

freight rate for anhydrous ammonia from Montana to Regina, Saskatchewan. The estimated rate is \$59.82 per tonne of anhydrous ammonia or its equivalent \$72.95 per tonne of nitrogen.[13] Given these figures, price of re-imported nitrogen would be \$221.55 + [2 x \$72.95] = \$367.44 per tonne of nitrogen which is slightly above the limit price in Saskatchewan market. It is our understanding that these five big companies meet the competition from the U.S. Gulf Coast in the U.S. market, yet the export price is still high enough, when the freight rate is added up, to make arbitrage impossible. Therefore, they get sound protection from the U.S. market while making a premium return in the Saskatchewan market.

This model yields a wholesale price \$365 per tonne of nitrogen, and the estimated cost of retail is approximately \$100 per tonne of nitrogen,[14] hence it predicts a price to farmers around \$465 per tonne of nitrogen (see Table 2). Given the actual price paid by farmers in Saskatchewan, which is approximately \$480 per tonne of nitrogen, the model confirms the farmers' concern over high fertilizer prices, and explains the reasons for high nitrogen prices in Saskatchewan.

5. Conclusions

Farmers in Western Canada have always been concerned that they pay too much for inputs. Our results support their concern. The Saskatchewan market is relatively small given the capacity of world

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[13] Personal communications with Mr. Rick Kellinf of PCS, Saskatoon, Saskatchewan, Winter, 1986.

[14] Blue, Johnson and Associates, August, 1985.

scale nitrogen plants and these companies appear to be limiting the entry of new firms, thus holding up prices and profits.

What should the government do when faced with an imperfect market, such as the fertilizer market? The recent announcement of the Saskatchewan Government to support an anhydrous ammonia plant at Regina is one alternative. While it is true this plant may increase the competition and thus lower prices to farmers, how do farmers guarantee themselves the government plant does not follow suit with the other corporate interests?

The government could regulate the price of anhydrous ammonia. This alternative is not likely to receive much support because of the past experience we have had with price controls. Farmer-owned companies, such as cooperatives, are currently in the industry and following the corporate interest, thus they do not appear to be the solution.

The economic performance of the farm economy is dependent upon the industrial organization of the agribusiness sector. Agricultural economists have spent too little attention on studying the structure and behaviour of this component of the farm economy. This paper demonstrates the usefulness and importance of such a study.

Table 1: Nitrogen Fertilizer Used in Saskatchewan, 1966-1985 (tonnes)

Year	Nitrogen (N)
1985	196,395
1984	289,261
1983	222,499
1982	191,974
1981	167,734
1980	142,700
1979	138,128
1978	104,825
1977	66,658
1976	56,351
1975	55,700
1974	49,328
1973	35,482
1972	20,707
1971	15,750
1970	10,052
1969	18,733
1968	40,491
1967	43,680
1966	31,153

Source: (1966-1977) Statistics Canada "Fertilizer Trade", (Stat. Can. Catalogue No. 46-207), (1978-1985) Western Canada Fertilizer Association and the Potash and Phosphate Institute.

Table 2: Export Prices of Anhydrous Ammonia to the U.S.A.

	Price of Canadian Exports of 82-0-0	Price of Canadian Exports of 82-0-0 on Actual N Basis	Price of the Rest of the World Exports of 82-0-0 on Actual N Basis on the Gulf Coast*
	Canadian $/tonne		
1980	142.03	173.21	---
1981	163.87	199.84	239.00**
1982	190.25	232.01	199.16
1983	186.32	227.22	210.78
1984	174.36	212.63	288.66**
1985	221.55		234.00

* Blue, Johnson and Associated, August 12, 1985, p. 40.

** Mid points of annual price ranges are assumed when yearly average prices are not provided.

Source: Statistics Canada, 65-202, data on exports by volume and value was used to compute export prices.

Table 3: Estimated Limit Price in Saskatchewan Nitrogen Market, 1984

Competitive Price, P_C \$/tonne	Price Elasticity of Demand for Nitrogen, $\lvert\mu\rvert$	Limit Price P_L \$/tonne	Cost of Retail[3] \$/tonne	Estimated Price of Nitrogen to Farmers \$/tonne	Price Paid by Farmers[4] \$/tonne
234[1]	.4	431	100	531	480
234	.6	365	100	465	480
220[2]	.4	405	100	505	480
220	.6	344	100	444	480

$$P_2 = P_C \left(1 + \frac{MES}{X_C \cdot \lvert\mu\rvert}\right)$$

MES = 99,791 tonnes per year.

$X_C = X_L + MES$ = 296,186 tonnes (1985).

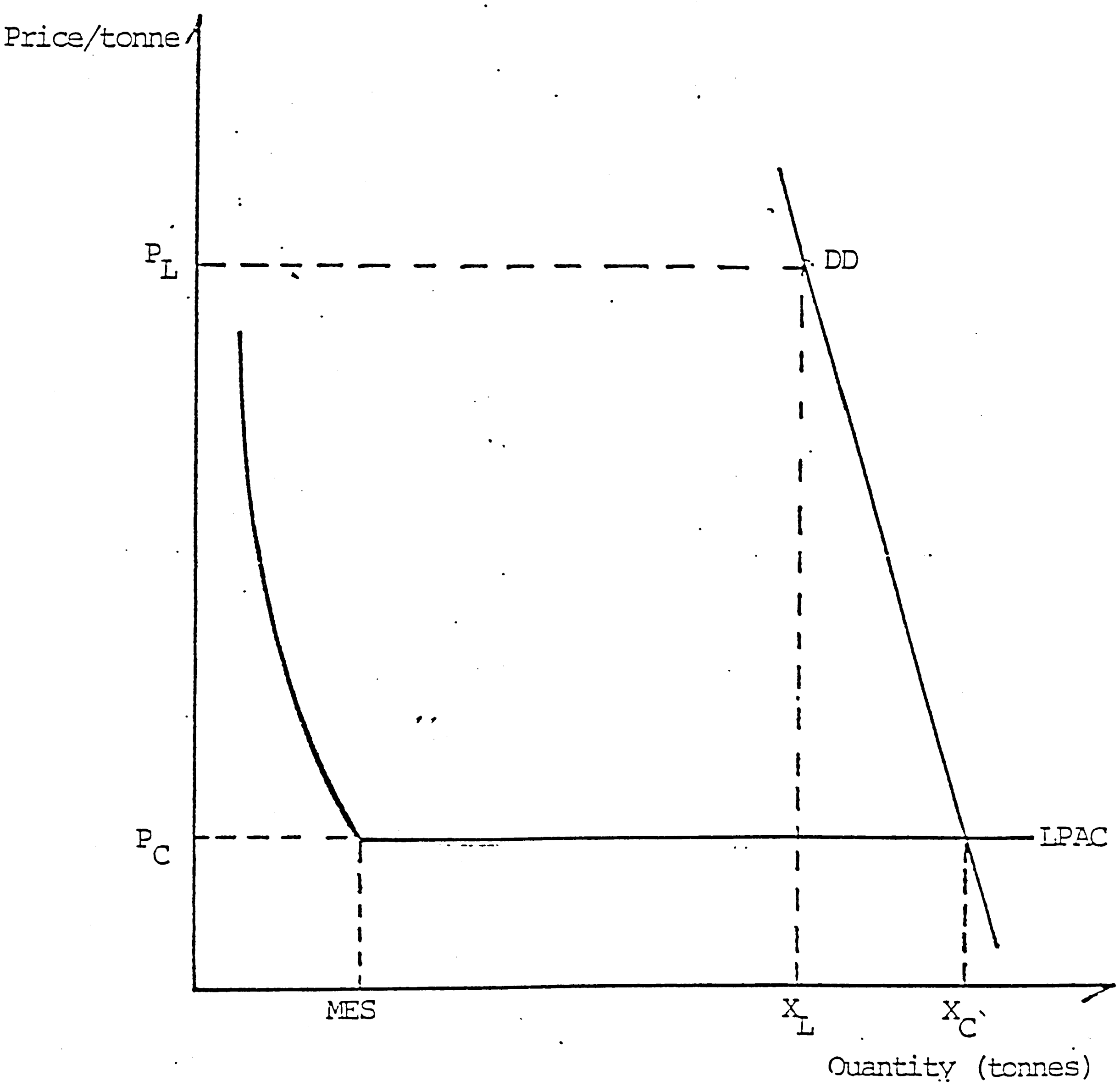
(1) Estimated average cost.

(2) Average cost computed by using Cominco data.

(3) Blue, Johnson & Assoc. report that estimated cost of retail is approximately \$100/tonne.

(4) As there is no official data collected in Canada on the price farmers pay for nitrogen, the authors surveyed a few local farmers to determine the price paid. All prices are on a per tonne of N_2 basis.

Figure 1



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