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POTENTIAL MARKET IMPACT OF A CORN/ETHANOL PLANT TO BE LOCATED IN SOUTHERN ONTARIO

(WORKING PAPER 8/86)

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SUMMARY

In late 1984, the Ontario Corn Producers' Association, the Canadian Renewable Fuels Association, and several private companies in the agri-business sector requested federal assistance to identify ethanol feedstocks from renewable agricultural sources and to assess their potential to be economically viable. On October 15, 1985, Elliot Hardey, the member for Kent, introduced a private members motion before the House of Commons in which he used ball park figures of 35 million bushels of corn to produce approximately 350 million litres of fuel ethanol in Ontario. In this study, we construct small mathematical simulation models with which we make some assessment of the ramifications that initiatives into commercial ethanol production may have for agricultural feed stock markets, particularly those in Southern Ontario.

It is demonstrated that upper limits on the size and number of ethanol production initiatives may be placed by the small size of Ontario's market for agricultural feedstocks at present and the degree to which transportation costs and trade barriers isolate the 'local' Ontario market for those feedstocks. However, these upper limits will be relaxed considerably if the Ontario corn production base continues to expand at the present rate. For this reason, we recommend that, should investors (public or private) see ethanol production as an attractive business venture, initial investments into ethanol production be kept to a modest capacity of 200,000 tonnes total or less of grain corn intake capacity and expanded incrementally in tandem with growth in the grain corn industry. This approach will prevent serious distortion of 'local' Ontario prices for agricultural feedstocks and, hence, will not seriously affect the solvency of such ethanol production initiatives.

Ethanol production from agricultural feedstocks is already becoming an area of government intervention abroad and these government policies will, in all probability, play a key role in determining the market orientation of any developing ethanol industry. In particular, the domestic support and tariff policies of Brazil, the European Economic Community and the United States will play a major role in determining the market outlook for both ethanol and its by-products. For this reason, any assessment of the potential for ethanol production from Canadian agricultural feedstocks must include both an assessment of such ethanol production initiatives competitive position vis-à-vis non-agricultural octane enhancers (such as lead and MMT) and

an assessment of their competitive position relative to foreign sources of ethanol. Future research regarding the probable competitive position of Canadian produced ethanol from corn feedstocks should be based on site specific analysis; a short list of possible locations could include locations such as Chatham, Goderich, Sarnia, St. Thomas/Port Stanley and Woodstock. Similar analysis could be conducted for ethanol production initiatives utilising Western Canadian barley as a feedstock.

From a theoretical perspective, this study is of interest because it illustrates how transfer costs (tariffs,transportation and handling costs) can serve to isolate local markets to some degree by the manner in which they limit the process of arbitrage. Information regarding the volume and direction of trade is used in tandem with information about transfer costs to illustrate how changes can occur in the 'World' Price - 'Local' Price basis. Although rather simple, this method can easily be extended to more complex simulation models as well as regression models to obtain results which more accurately reflect market behaviour.

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1. INTRODUCTION AND BACKGROUND

In the mid-1970s, alcohol fuels entered the public agenda because of two concurrent movements. The petroleum supply disruption and the resulting dramatic escalation of imported crude oil prices spurred substantial interest in the production of liquid fuels from domestically abundant renewable resources. Consequently, many western nations took steps to reduce their dependence on uncertain foreign oil supplies. Environmental concerns have also come more to the fore over the last 15 years. Environmentalists have lobbied long and hard for the removal of lead and Methylycylopentadienyl Mangenese Tricarbonyl (MTT) as the principal octane enhancers in gasoline.

More recently, additional pressure for government leadership in this area has been brought to bear by agricultural producers. In coarse grain markets in particular, record production levels and weak demand have led to record stockholdings and historically depressed prices. This development has left policy makers searching for ways to utilize stocks and support farm prices.

In late 1984, the Ontario Corn Producers' Association, the Canadian Renewable Fuels Association, and several private companies in the agri-business sector requested federal assistance to identify ethanol feed stocks from renewable agricultural sources and to assess their potential to be economically viable. On October 15, 1985, Elliott Hardey, the member for Kent, introduced a private members motion before the House of Commons in which he used ballpark figures of 35 million bushels of corn to produce approximately 350 million litres of fuel ethanol in Ontario. Such an initiative (whether one plant or a collection of plants) with an intake capacity of almost 1 million tonnes of corn, or 20 percent of present Ontario corn consumption, is likely to have substantial effects on the market for Ontario feedstocks.

In this paper, the ramifications that initiatives into commercial ethanol production may have for agricultural feedstock markets are examined. In the interests of clarity and brevity, the analysis is primarily focused on those ethanol production initiatives which pertain to Ontario and, particularily, to proposals for ethanol production from grain corn feedstocks. Nevertheless, the approach used here can easily be extended to other regions such as the prairie provinces, after adjustments are made to capture the peculiarities specific to those regions.

Other analysts have indicated that substantial economies-of-scale exist in ethanol production and that these economies-of-scale effectively place a lower limit to the size of any viable ethanol operation (Smith 1985, Beaulieu and Goodyear 1985). It seems that most of these economies-of-scale are realized by plants with 20 million litres of fuel ethanol output capacity or greater, or approximately 60,000 tonnes corn intake capacity (Smith, 1985). In this study, a small simulation model is used to demonstrate that upper limits on the size and number of ethanol production initiatives may be placed by the small size of Ontario's market for agricultural feedstocks and the degree to which transportation costs and trade barriers isolate the 'local' Canadian markets for those feedstocks. Please see appendix 1 for a cautionary note regarding analysis of this type.

2. HOW WORLD (U.S.) PRICES AND TRANSFER COSTS ESTABLISH UPPER AND LOWER BOUNDS FOR LOCAL (CHATHAM) PRICES[1]

The United States is the world's largest producer and exporter of coarse grains. For this reason, we refer to the Chicago price for corn in lieu of a world price; we use the Chatham price for corn as the local Canadian price. Some may argue for the use of the Toledo price rather than the Chicago price, but this would not affect the substantive findings of this analysis.

Canada is a small country as far as corn production and exports are concerned and, consequently, Canadian corn producers are subject to a price determination process which is, for the most part, exogenous to their own production environment. However, to the extent that the process of arbitrage is impeded by barriers to trade, handling costs and transportation costs, local supply and demand conditions do have a role to play.

The opening of trade between regions has the effect of bringing the combined demand of the regions to bear on the combined supply conditions, through the process of arbitrage. This is illustrated by the third section of Figure 1, where the combined supply and demand curves for the two regions are shown. These curves have been added horizontally, combining the quantities that would be demanded or supplied in the two regions in response to selected levels of price. The intersection of the combined curves indicates a final equilibrium price of Oc and total output n. Notice that this intersection will always occur between the prices that would hold in each of the regions if they were isolated.

In the above paragraph, the discussion centres on the aggregation of regional supply and demand curves to determine price and quantity traded under the assumption that transfer costs were zero. It should be observed that the two regions would have different prices in the absence of trade and that this difference would give rise to trade flows from region Y (where prices were low), to region X (where prices were high). This process would continue until prices in the two regions were equalized. Obviously, this is an over-simplification; there are costs associated with the transfer of a commodity from one region to another. It follows, therefore, that trade will not completely equalize commodity prices; instead, the prices in the two regions will move toward each other until they differ exactly by the cost of transfer. It is relatively simple to illustrate the modifications that are required by the insertion of transfer costs.

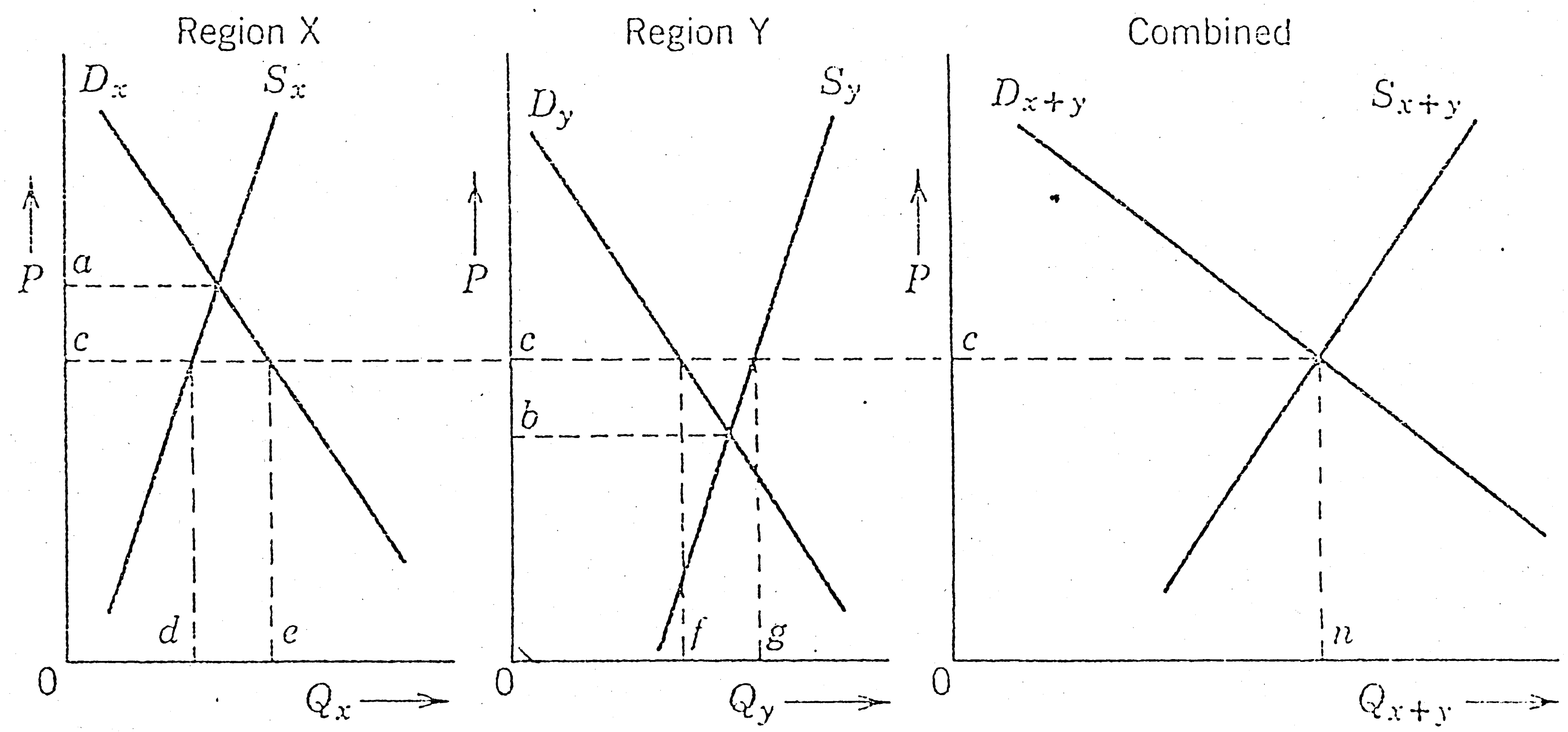


FIGURE 1 The trade between two regions as a result of differences in supply and demand functions.

In Figure 1, we used the horizontal summation of regional supply curves and demand curves to obtain aggregate functions for the combined regions. This procedure was appropriate in the absence of transfer costs because prices with trade would be identical in the regions. With the addition of transfer costs, however, equilibrium prices will be lower in the exporting regions than in the importing regions. In short, supply curves and demand curves can no longer be added directly but must be "positioned" to reflect transfer costs. This is indicated in Figure 2 where the supply and demand curves for region Y have been shifted upward by an amount t representing the unit cost of interregional transfers. Notice that, with this construction, any horizontal line across the diagrams no longer represents equal prices in the two regions but, instead, prices differing by transfer costs.

Presently, our model of the market place is still inadequate to encompass the realities of the Ontario corn market. First, with improving production technologies and new corn cultivars, Ontario has moved from a large import position to a large export position over the past 15 years. A consequence of this has been a switch in the discount/premium relationship between Chicago and Chatham prices. Second, rather than being spatially separated, aggregate production sources emanating from two point sources (as Figures 1 and 2 imply), Canadian and American producers are spread over the region between (and beyond) the Chicago and Chatham markets (see Figure 3). When one combines this point with a third observation, that total transportation costs increase at a decreasing rate with distance and volume (Transport Canada 1985, see also Figures 4B and 5), one would conjecture that, as production and trade levels shift, prices in Chatham would only approach the Chicago price plus or minus transfer costs asymptotically (see Bressler and King 1970, Chapters 7 to 10 for additional details). Within the boundaries established by the Chicago price, plus or minus transfer costs, there may exist considerable opportunities for Ontario's domestic market conditions to play a role.[2]

In Figure 6, we illustrate the spatial nature of the arbitrage process in the corn market. If the marketplace and trade between countries was perfectly frictionless (no transfer costs), then $P_o^1 = P_u$

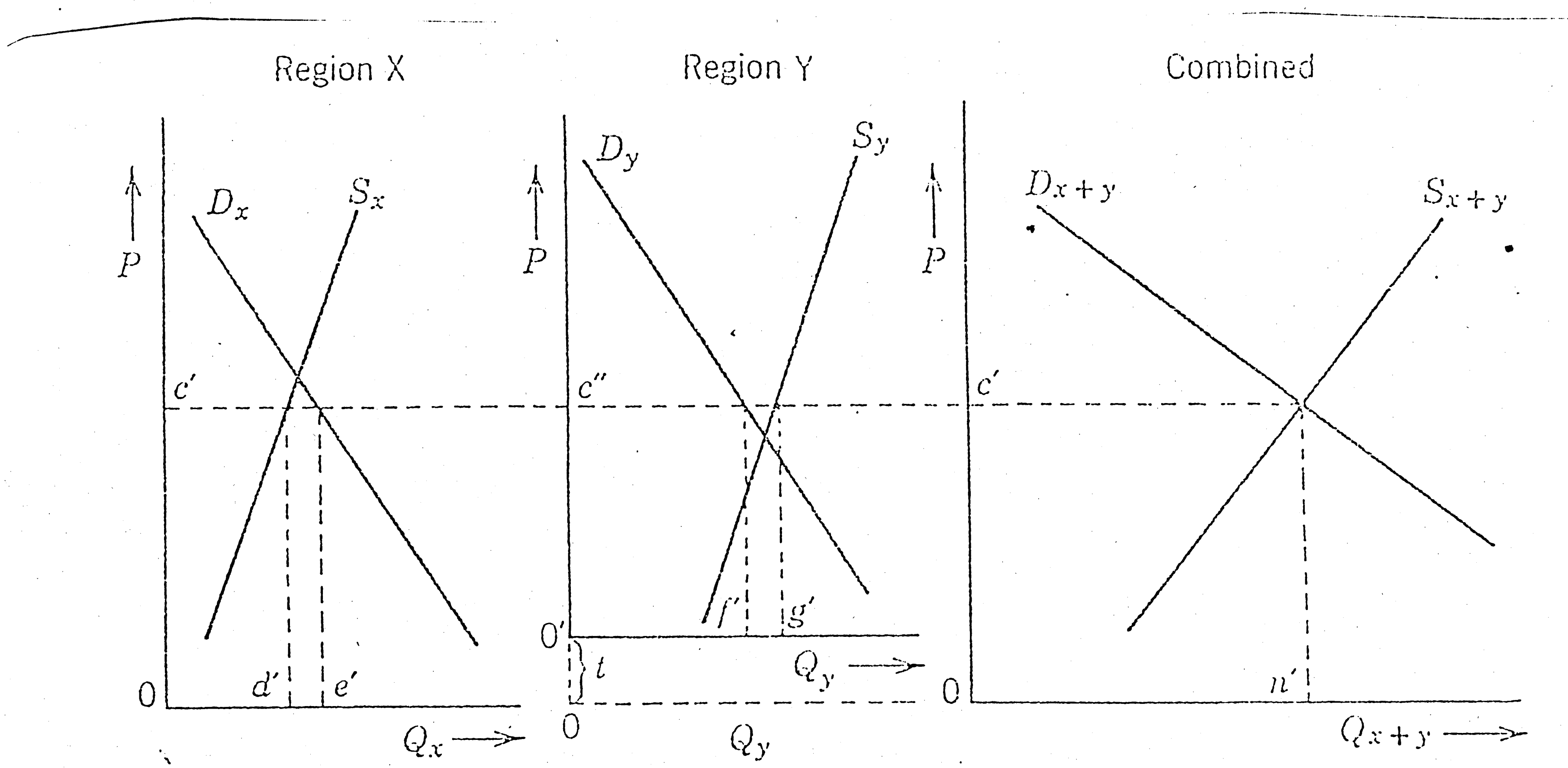
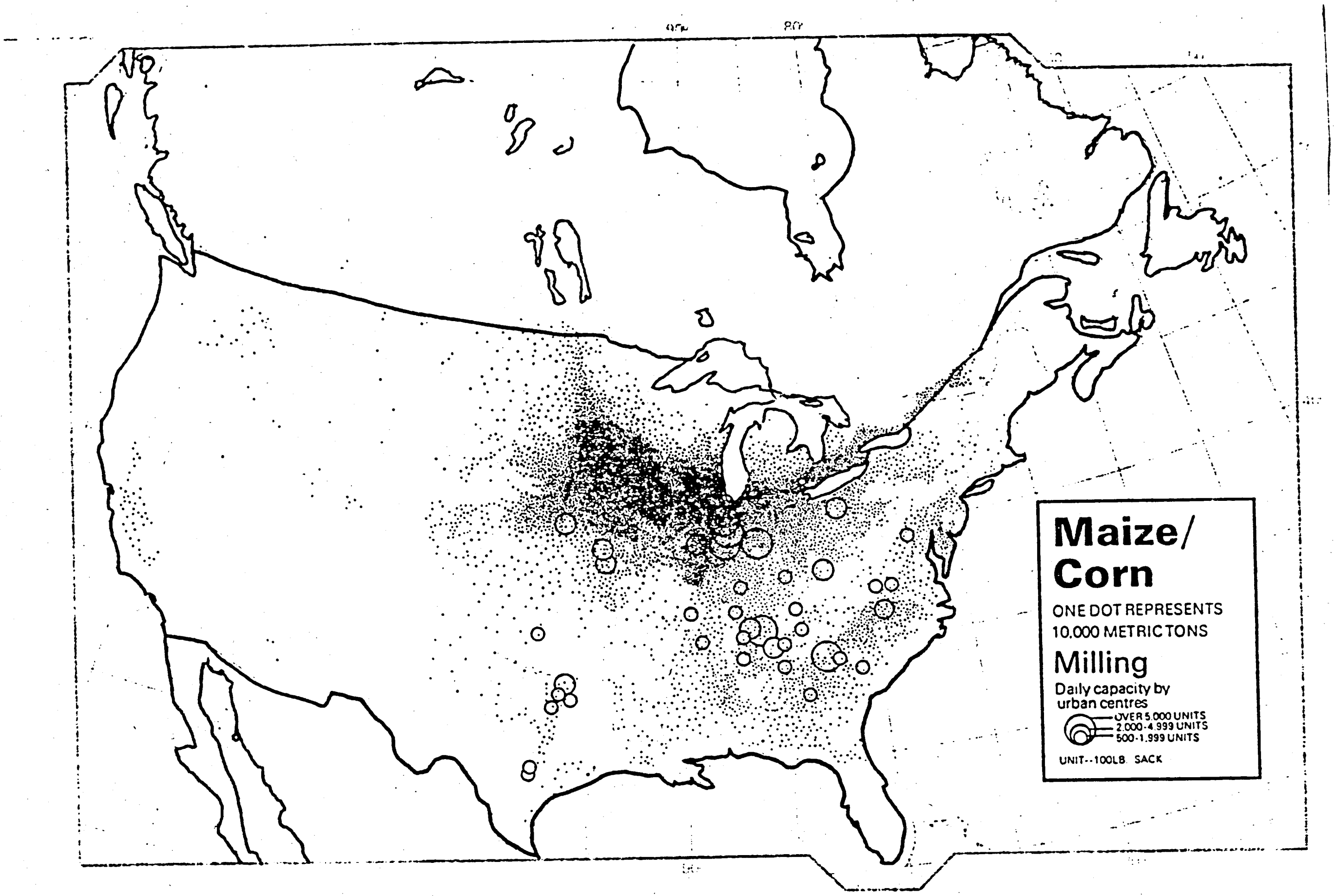
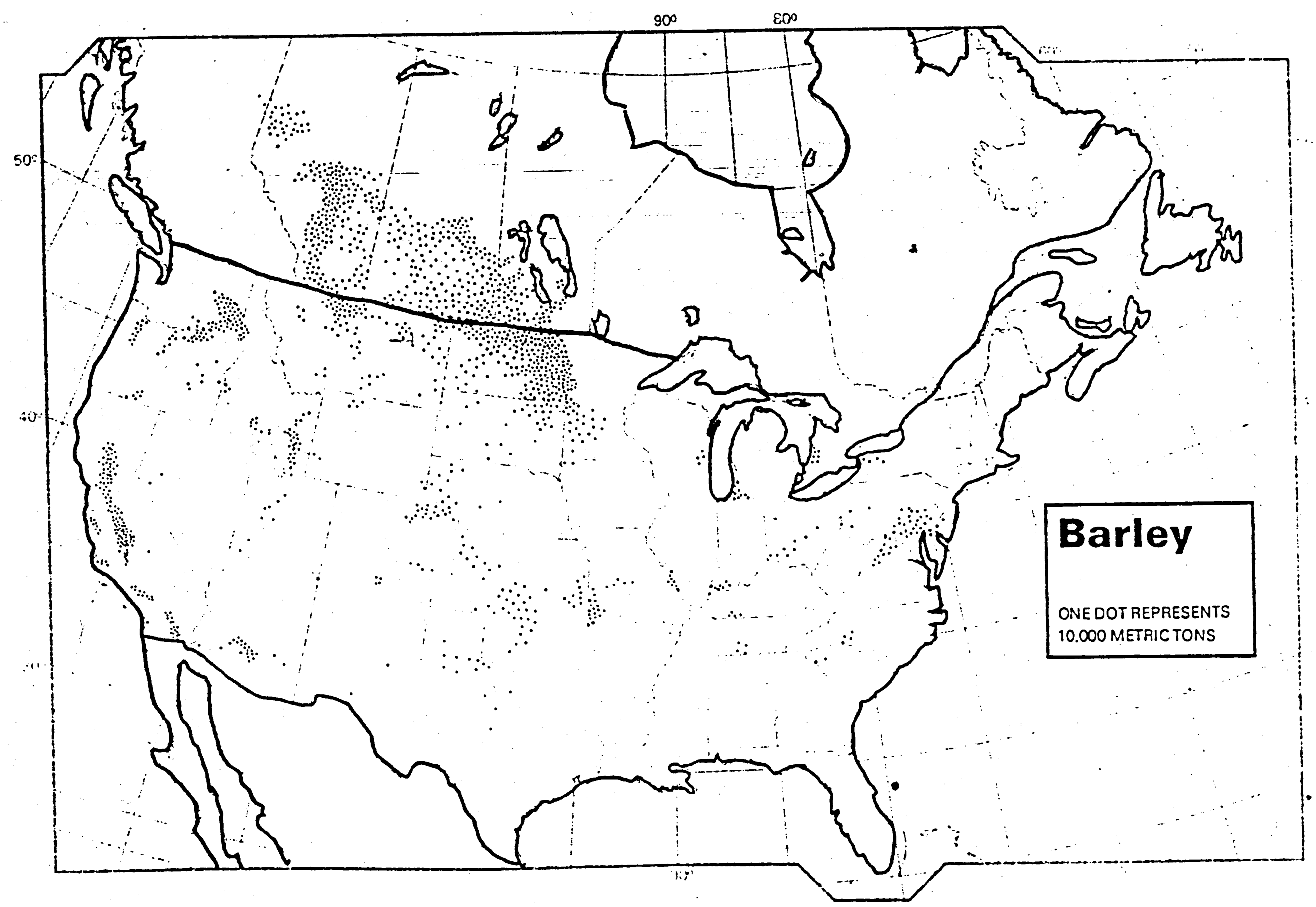


FIGURE 2 The effects of transfer cost (t) on prices and trade (compare with Figure 1).

FIGURE 3. THE SPATIAL DISTRIBUTION OF CORN AND BARLEY PRODUCTION IN NORTH AMERICA





SOURCE: Chapman and Sherman (1967)

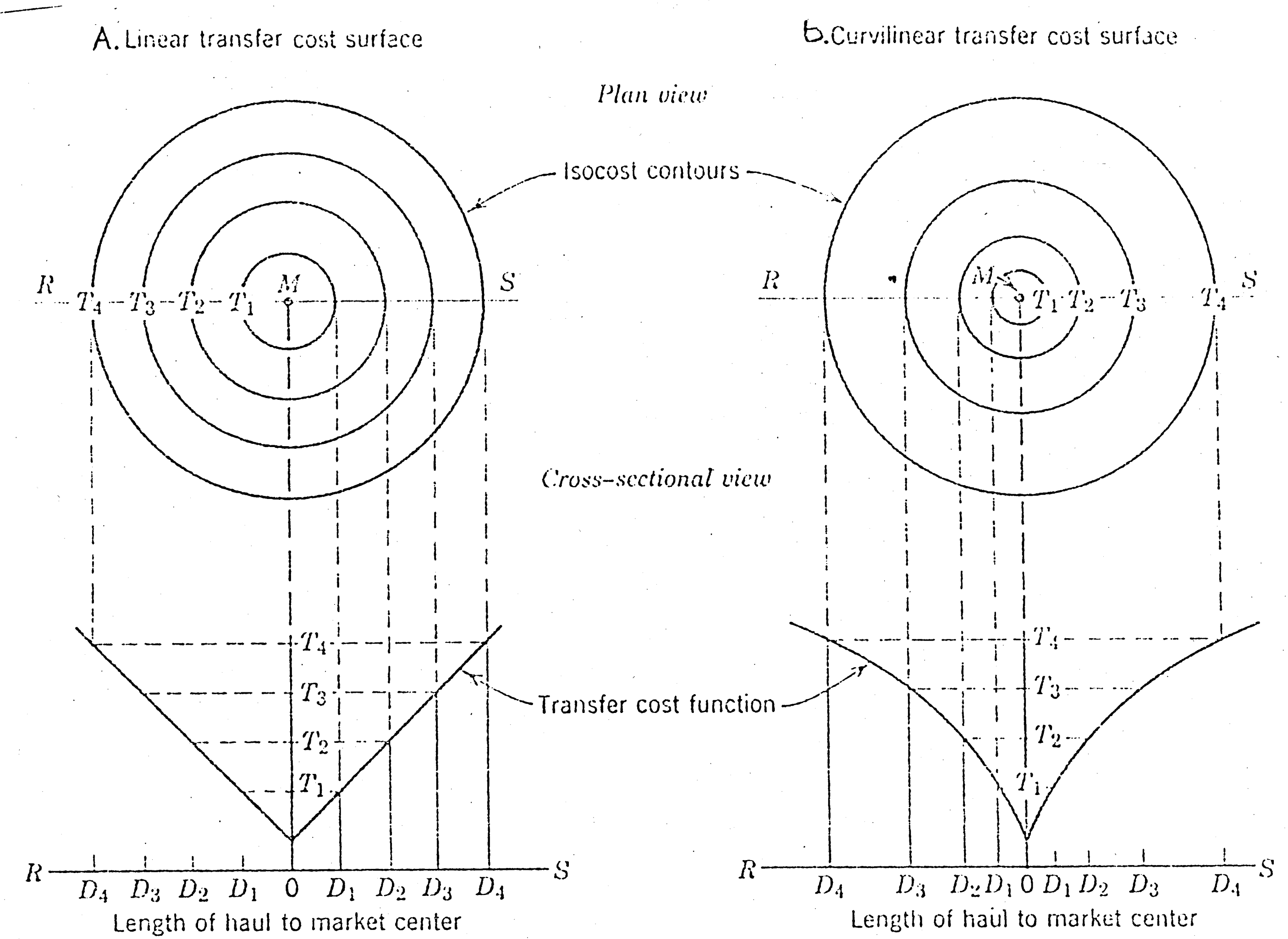


FIGURE 4 Transfer cost surfaces with linear and curvilinear functions.

SOURCE: Bressler and King (1970), Canada Grains Council (1975), and Westburn Consultants (1982).

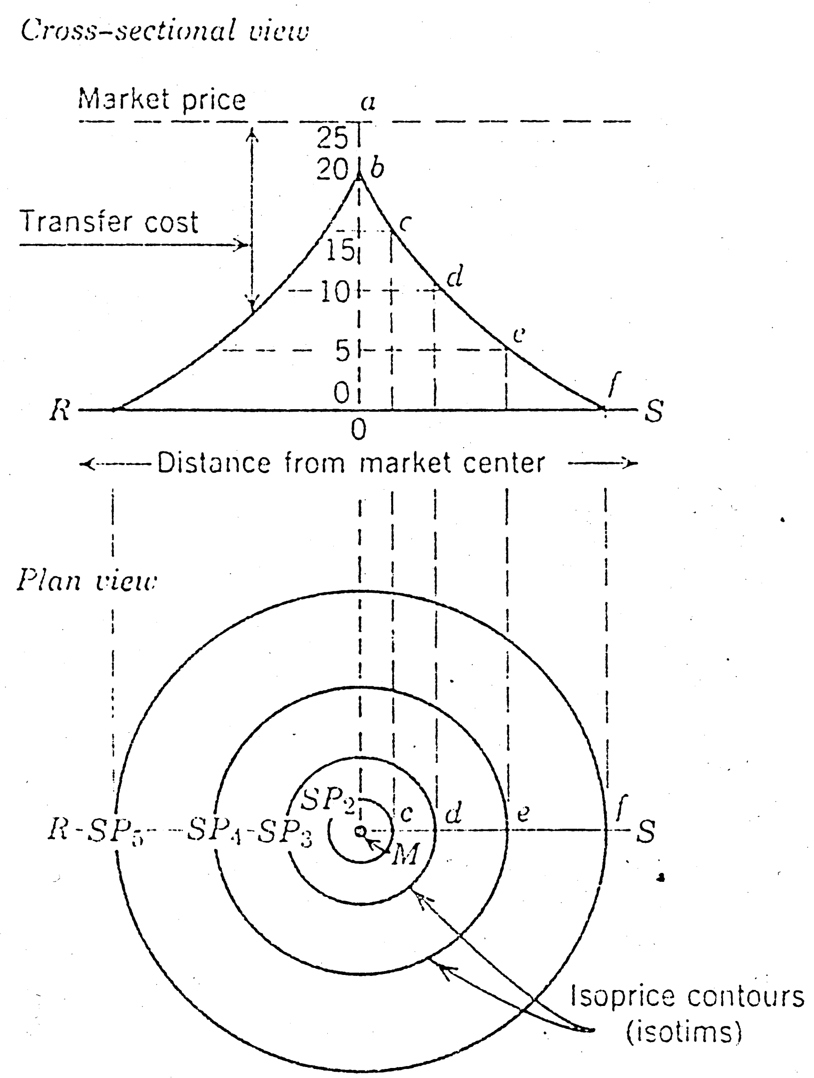


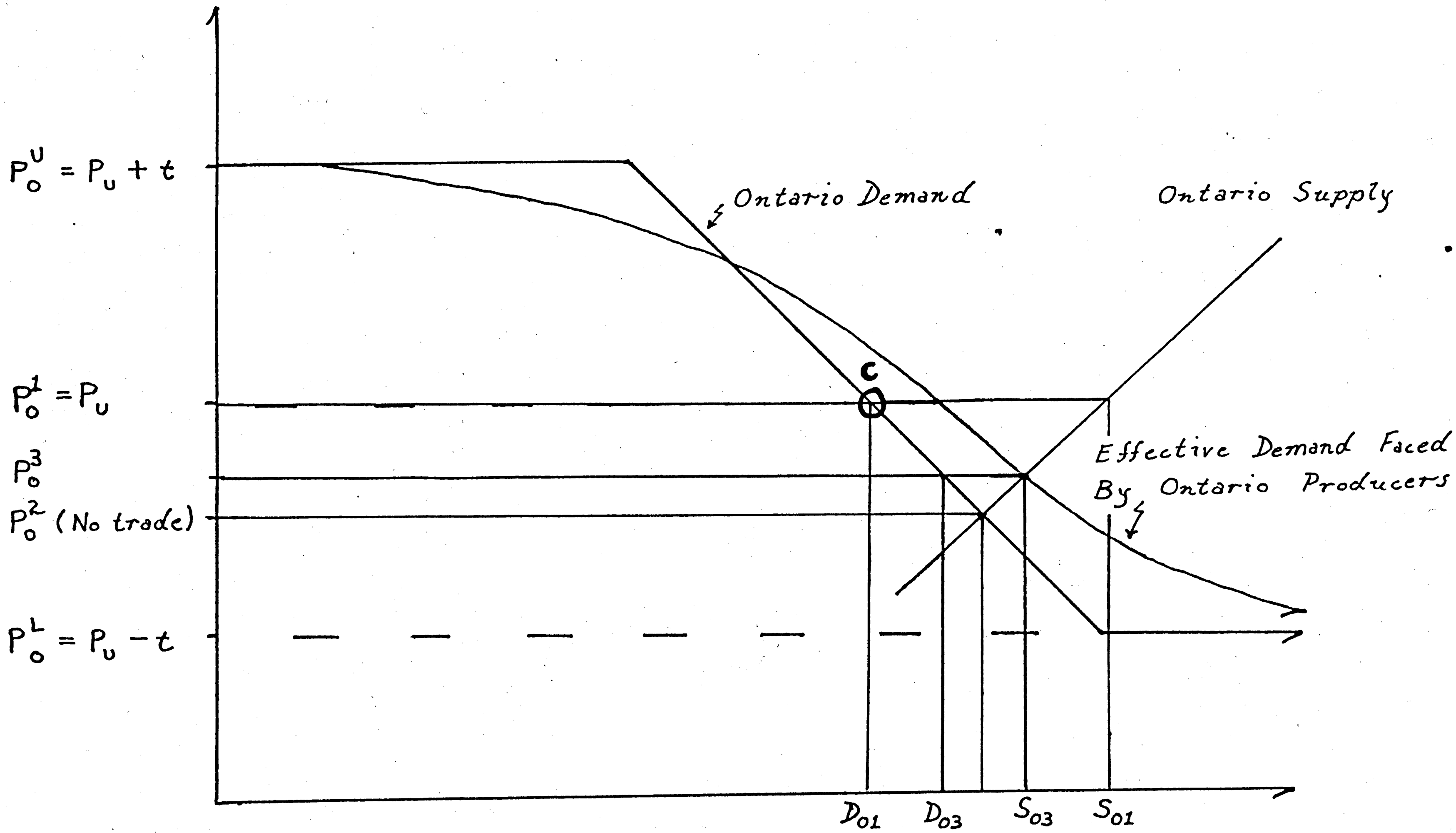
FIGURE 5 The site-price surface for a single market.

SOURCE: Bressler and King (1970), Canada Grains Council (1975) and Westburn Consultants (1982).

(the 'world' price) would prevail and Ontario would produce S_{o1}, consume D_{o1} and export ($X_{o1} = S_{o1}-D_{o1}$) the remainder to eastern Canada. However, we know that the corn market is not frictionless and that Canada's domestic market is insulated to some degree by the existence of transportation and other costs. If there were a physical barrier between Ontario and the U.S., then the Canadian market would operate and respond solely to domestic market conditions between the price boundaries established by P_u plus or minus transaction costs (P_o^U, P_o^L). However the Canadian market is not geographically separated from the American market and, consequently, is not insulated to the same degree; we have conjectured that a smooth, switching function would capture this relationship (Bressler and King 1970, Canada Grains Council 1975, Westburn Consultants 1982). This type of switching function is considered appropriate for a number of reasons. First, transportation costs increase with larger volumes and greater distances, but their rate of increase declines as volume and distance increase (Canada grains Council 1975, Westburn Consultants 1982, Transport Canada 1985). Presumably, these transportation costs will follow the same general pattern whether a country is on an import or an export basis; consequently, we characterize the function as approximately symmetrical about its inflection point.[3] Finally, we postulate that the transition phase (around the inflection point) is reasonably smooth simply because we have no reason a priori to presume otherwise. This characterization yields the prediction that price P_o^3 would prevail on the Ontario market, while Ontario production would be S_{o3} and consumption D_{o3} with the difference ($X_{o3} = S_{o3}-D_{o3}$) being shipped elsewhere, including a fair proportion going to eastern Canada; the difference between P_o^1 and P_o^3 is the Chicago/Chatham corn basis in the real world.

In Figure 7, we illustrate how technological innovations have resulted in successive shifts of the corn supply curve in Southern Ontario. These supply shifts have resulted in a decline in the quoted Chatham price relative to the quoted Chicago price and have taken Southern Ontario from a corn deficit area to a corn surplus area. There are two items worthy of particular note here and both relate to the facts that transportation costs are positive and non-linearly related to distance (Transport Canada) and that the producing regions of Canada and the United States are not

FIGURE 6. A SCHEMATIC REPRESENTATION OF THE PRESENT ONTARIO CORN MARKET



spatially separated(Chapman and Sherman). First, one observes that the Ontario (Chatham) price for corn was higher than the American (Chicago) price even when net trade was zero (see point A, Figure 7), and that at the actual point where the Ontario price was equivalent to the American price, Ontario registered a significant trade surplus (see point B, Figure 7). It is also at this point where the function 'Effective Demand Faced by Ontario Producers' has its inflection point; this is of importance later when we discuss a simulation model of the corn industry.

3. PRELIMINARY DISCUSSION REGARDING THE IMPACT OF AN ETHANOL PLANT USING CORN AS A FEEDSTOCK

The construction of an ethanol plant, or a number of plants, would result in a shift in the demand functions in the Ontario market. Critical to the discussion of the relative impacts on prices and quantities is the precise placement of the Ontario supply curve in relation to the transition phase of the switching effective demand schedule. This is illustrated in Figure 8.

Supply schedule S_{oa} can be considered representative of the period when Ontario was a significant importer of corn. If an ethanol plant had been placed in the Ontario market at that time, it would result in a very small price increase from P_{ao} to P_{a1}, while resulting in a substantial increase in imports (compare IaO and Ial in Figure 8). This part of the curve is, however, no longer relevant to the Ontario corn market.

The real point of contention is whether the present supply schedule's placement can best be represented by S_{ob} or S_{oc}. If S_{oc} is the true representation, the construction of an ethanol plant will only modestly increase the Ontario price from P_{co} to P_{c1}, while substantially reducing Ontario exports (compare $S_{c0}-D_{c0}$ to $S_{c1}-D_{c1}$ in Figure 8). However, if S_{ob} is the true representation, the construction of an ethanol plant could substantially increase the Ontario price from P_{b0} to P_{b1} and result in only a modest change in Ontario's export position (compare $S_{b0}-D_{b0}$ to $S_{b1}-D_{b1}$ in Figure 8). It is our

FIGURE 7. HYPOTHETICAL IMPACTS OF TECHNOLOGICAL IMPROVEMENTS AND SHIFTING COMPARATIVE ADVANTAGE ON THE RELATIONSHIP BETWEEN THE AMERICAN (OR WORLD) PRICE AND THE LOCAL ONTARIO PRICE

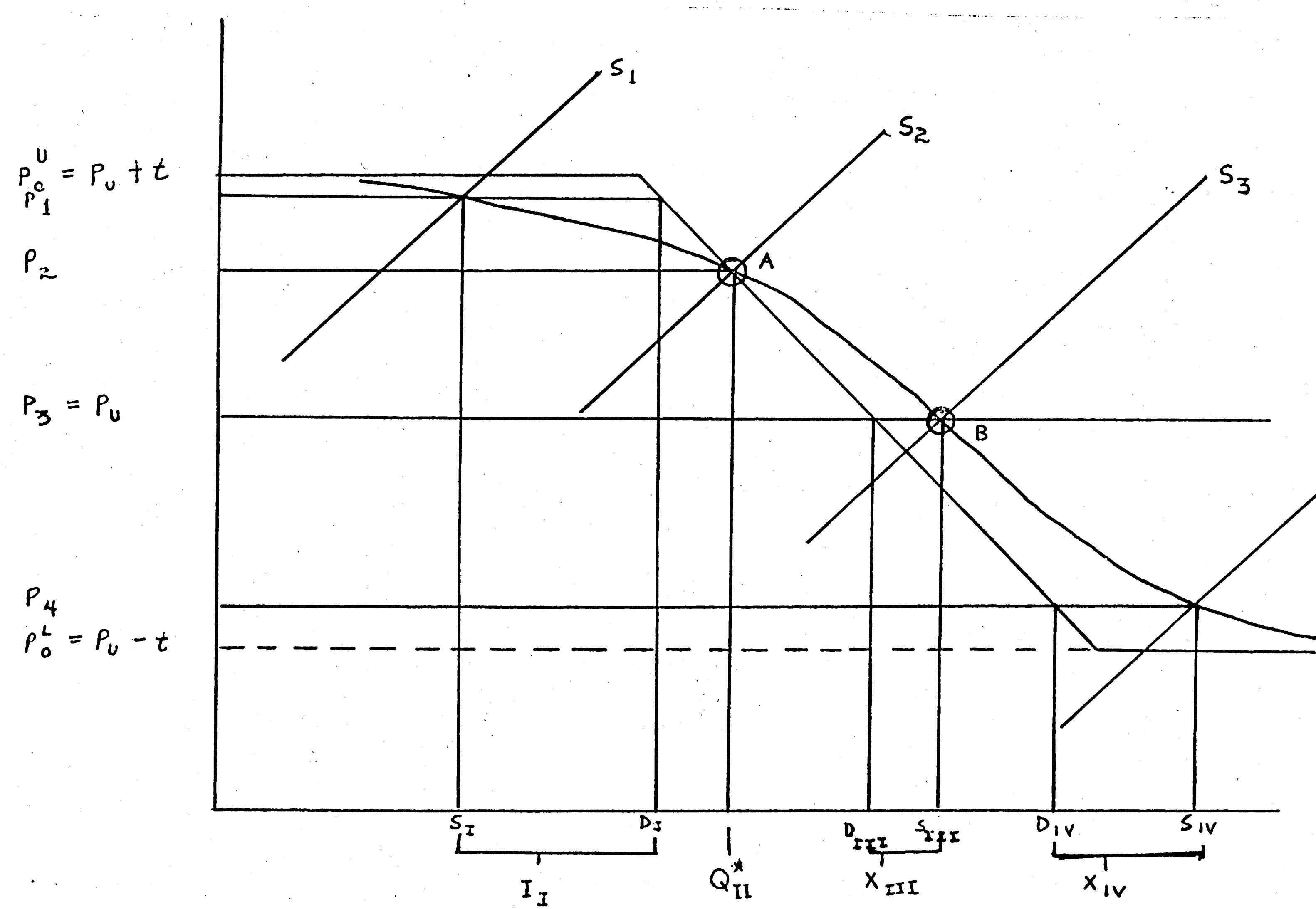
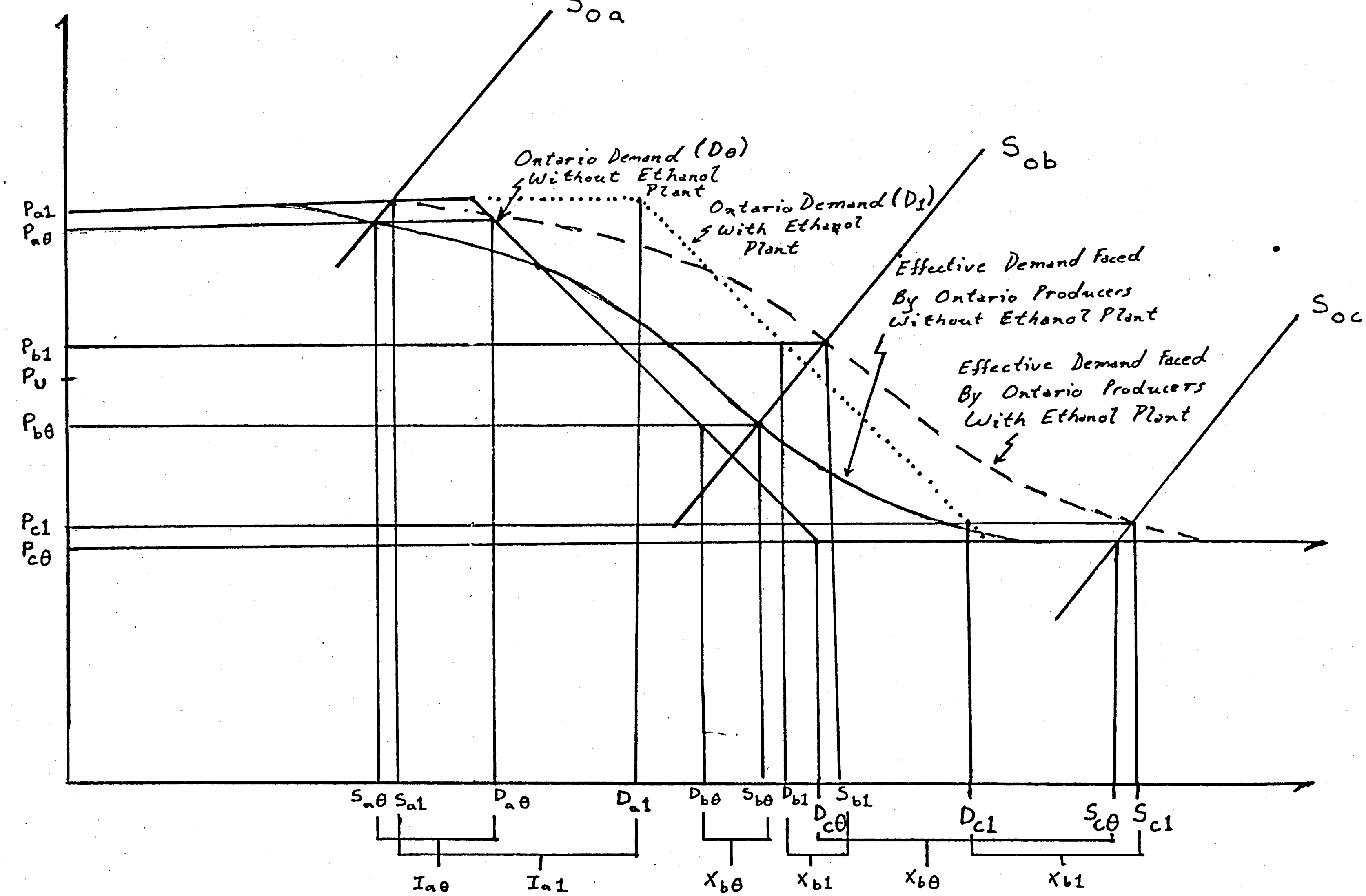


FIGURE 8. POTENTIAL IMPACTS OF A NEW ETHANOL PLANT ON THE ONTARIO CORN MARKET



contention that S_{ob} is the more accurate characterization of the present Ontario corn market, although this assessment is subject to debate. For this reason, firms wishing to invest in ethanol plants must be cautious when determining the size and number of plants to be located in southern Ontario since the price impacts on agricultural feedstock markets may well affect their solvency. Ethanol firms' solvency can be affected in two ways. First, changes in the relative prices of inputs and by-product outputs will alter the breakeven price required for ethanol and, thus affect its competitive position relative to other (non-agricultural) octane enhancers. Second, changes in the Chicago-Chatham corn basis would alter the competitive position of Canadian-produced ethanol relative to American-produced ethanol. In the section which follows, we construct a small simulation model which we use to obtain more precise assessments of the probable consequences for agricultural markets of new initiatives into ethanol production. A sensitivity analysis regarding the relative placement of the supply and demand schedules has been included as Appendix 3, given that the characterization presented here is subject to some debate.

4. THE MODEL AND SOME SIMULATION RESULTS

4.a The Model

In an effort to obtain more precision in our estimates of the potential market impacts of ethanol production from corn in Southern Ontario, a small, three region, simulation model providing a simple characterization of the North American corn market was constructed. It was then subjected to demand shocks which serve as suitable proxies for the effects that ethanol plants with various capacities would have. The model is specified as follows:

Corn demand relationships:

$$D_o = (a_o \cdot P_o^{a_1})/Z \qquad (1)$$

$$D_e = C_o \cdot P_e^{C_1} \qquad (2)$$

$$D_u = e_o \cdot P_u^{e_1} \qquad (3)$$

Corn supply relationships:

$$S_o = b_o \cdot P_o^{b_1} \qquad (4)$$

$$S_e = d_o \cdot P_e^{d_1} \qquad (5)$$

$$S_u = f_o \cdot P_u^{f_1} \qquad (6)$$

Corn price relationships:

$$P_o = P_u / (1 + G_1 . \ln(X_o - X_k)) \text{ if } X_o > X_k + 2.7 \qquad (7a)$$ [5,6]

$$P_o = P_u / (1 - G_1 . \ln(X_k - X_o)) \text{ if } X_o < X_k - 2.7 \qquad (7b)$$

$$P_o = P_u / (1 + (G_1/2.7) . (X_o - X_k)) \text{ otherwise} \qquad (7c)$$

$$P_e = (I_e/D_e) . 2.845 . \ln(I_e) + P_u \text{ if } X_o < 0 \qquad (8a)$$

$$P_e = (I_e/D_e) . 2.845 . \ln(I_e) + P_o \text{ if } X_o > I_e \qquad (8b)$$

$$P_e = (I_e/D_e) . 2.845 . \ln(I_e) + ((X_o . P_o + (I_e - X_o) . P_u)/(D_e - S_e)) \text{otherwise} \qquad (8c)$$ [7,8]

Corn identities:

$X_o = S_o - D_o$ (9)

$I_e = D_e - S_e$ (10)

$D_o + D_e + D_u = S_o + S_e + S_u - K$ (11)

where:

D_o is the demand for corn in Ontario

D_e is the demand for corn in eastern Canada

D_u is the demand for corn in the United States (U.S.)

S_o is the supply of corn in Ontario

S_e is the supply of corn in eastern Canada

S_u is the supply of corn in the United States

P_o is the price of corn in Ontario

P_e is the price of corn in eastern Canada (Montreal)

P_u is the price of corn in the United States

X_o are regional exports of corn from Ontario. Obviously, if they are negative, they represent imports.

I_e are regional imports into Eastern Canada. Obviously, if they are negative, they represent exports.

X_k is the export level at which the price linkage equation has its inflection point and was obtained by conducting a grid search and subjectively assessing whether the results were consistent with the limited data available (see appendix 3).

K are exports from North America

Z parameter used to subject the model to demand shocks

a_o, a_1, b_o, b_1, c_o, c_1, d_o, d_1, e_o, e_1, f_o, f_1
are parameters obtained from a survey of the literature (see also Meilke, 1984, and Krakar, 1985).

Equations (7a), (7b) and (7c) are mathematical expressions which combine to approximate the Effective Demand faced by Ontario Producers' curve shown in figures 6 through 8.

Equations (81), (8b) and (8c) approximate the linkages between Eastern Canadian prices, Ontario prices and American prices.

We specify a switching natural logarithm function for the relationship between Chatham and Chicago corn prices (equations 7a, 7b and 7c). This helps to capture the spatial nature of the arbitrage process and the fact that many producers (particularly in the United States) are physically located between Chicago and Chatham (Figure 6). The price into eastern Canada (Montreal) is presumed to be an appropriately weighted average of the Chicago and Chatham prices, tariffs (when applicable), transportation and transaction costs; we presume that the largest proportion of the Ontario corn surplus are shipments eastern Canada. The simulation results using reasonable parameter values and market levels in the model and subjecting it to demand shocks of various sizes are summarized in Table 1.

4.b Ethanol Production Shocks with the Present Agricultural Production Base

An examination of Table 1 indicates that the 50,000 tonne capacity plant would likely have a minimal impact on the Southern Ontario corn market. However, it would lead to an approximate 10 percent decline in corn exports from Southern Ontario, ceteris paribus. Plants with capacity intakes totalling 150,000 tonnes of corn could result in a price increase of around 1 percent while plants with capacities in the area of 250,000 tonnes could result in a price increase slightly in excess of 2 percent.

Plants with total capacity summing to 500,000 tonnes would have a substantial effect on the "local" price on the Ontario market. Prices in Chatham could rise by as much as 10 percent, while prices in eastern Canada could rise by as much as 2.7 percent. Exports of corn from Southern Ontario would decline to 44 percent of their present levels. Total shipments into eastern Canada (Quebec and Atlantic Canada) from all sources would decline as a total, but this would be primarily due to the drop in shipments from Ontario to the east. Actual imports to the east from the U.S. would increase from 600 to 706 thousand metric tonnes. These results indicate that plants with capacity intakes totalling 200 000 tonnes or less are unlikely to result in substantial price changes in the Ontario market, although Ontario's export balance will probably be reduced substantially. However, ethanol production initiatives with capacity intakes totalling 250,000 tonnes or more could result in substantial changes to Ontario market prices and, consequently, could have serious repercussions for the solvency of those initiatives.

TABLE 1.A POTENTIAL ONTARIO CORN MARKET IMPACTS OF ETHANOL PRODUCTION - LEVELS -

Approximate total capacity intake(000 tonnes)	0	50	150	250	500	800	1 150
Value of Z	1.00 (Baserun)	0.99	0.97	0.95	0.90	0.85	0.80
Variable[a, b]							
De	1 400	1 398	1 395	1 391	1 383	1 382*	1 381*
Do	4 600	4 642	4 726	4 803	4 945	5 186	5 487
Du	140 000	139 982	139 948	139 920	139 900	139 800	139 663
Ie	1 000	998	994	990	981	980	979
K	59 400	59 400	59 400	59 400	59 400	59 400	59 400
Pe	155.84	156.29	157.18	158.03	160.11	160.37*	160.73*
Po	137.02	137.37	138.36	140.21	150.60	154.79	156.64
Pu	145.00	145.05	145.14	145.21	145.26	145.52	145.88
Se	400	400	401	401	402	402*	402*
So	5 000	5 003	5 012	5 029	5 120	5 155	5 170
Su	200 000	200 019	200 056	200 085	200 107	200 215	200 362
Xk	200	200	200	200	200	200	200
Xo	400	361	286	226	175	-31	-317

TABLE 1.B POTENTIAL ONTARIO CORN MARKET IMPACTS OF ETHANOL PRODUCTION - PERCENTAGES -

Approximate total capacity intake(000 tonnes)	50	150	250	500	800	1 150
Value of Z	0.99	0.97	0.95	0.90	0.85	0.80
	- percentage change from baserun -					
De	-0.13	-0.38	-0.63	-1.21	-1.29*	-1.36*
Do	0.92	2.74	4.42	7.49	12.73	19.28
Du	-0.01	-0.04	-0.06	-0.07	-0.14	-0.24
Ie	-0.20	-0.60	-0.99	-1.91	-2.00*	-2.10*
K	-	-	-	-	-	-
Pe	0.28	0.86	1.40	2.74	2.91*	3.14*
Po	0.26	0.98	2.33	9.92	12.97	14.32
Pu	0.03	0.09	0.14	0.18	0.36	0.60
Se	0.06	0.17	0.28	0.54	0.54*	0.54*
So	0.06	0.24	0.58	2.39	3.10	3.40
Su	0.01	0.03	0.04	0.05	0.11	0.18
Xk	-	-	-	-	-	-
Xo	-9.76	-28.49	-43.60	56.29	-107.71	-179.16

a All prices are in the $C/metric tonne; all quantities are in thousands of metric tonnes.

b Parameters used are estimates selected from Meilke (1984, p. 9 and p. 88) and Krakar (1985, Tables 3 through 9). Parameter values selected for a_1, b_1, c_1, d_1, e_1, f_1, g_1, and X_k were -0.35, 0.25, -0.45, 0.20, -0.4, -0.3, 0.011 and 200 respectively.

* These Eastern Canadian observations are beyond the relevent range of our model's specification. Consequently, we imposed a strict relationship between the American and Eastern price beyond the 500,000 tonne impact.

4.c Ethanol Production Shocks in 1990 Given Current Trends in Corn Production

As it stands, the simulation model is long-term in that the elasticities used are those that reflect the full adjustment to a particular market shock. However, the model is only medium term in the sense that shifts in comparative advantage (relative to the United States) have not been explicitly incorporated in the modelling framework. We can rectify this shortcoming by placing anticipated future levels for important variables into the model and conducting sensitivity analysis as we did in the preceding section.

The production base of the Ontario corn industry has expanded rapidly over the last few years and does not yet show signs of slowing. Consequently, some analysis anticipate that, by 1990, Ontario will be shipping as much as 1.8 million tonnes of corn annually to other destinations (Meilke, 1984). In 1985, close to 1 million tonnes of corn was shipped from the region, but the year is thought to be atypical of prevailing trends. In any case, it seems likely that in 1990 the Ontario corn industry relative to effective demand will be in a considerable surplus situation and the supply situation will be much like the curve S_{oc} in Figure 8. In Figure 8, compare the difference in the magnitude of price change when S_{ob} prevails and a demand shift occurs (P_{bo} to P_{b1}) to the magnitude of price change when S_{oc} prevails and a demand shift occurs (P_{co} to P_{c1}). Hence, even if the larger ethanol production initiatives examined in this paper are in place in 1990, local Ontario prices are unlikely to be significantly altered.

To verify this assessment, we took values which were consistent with other analysts' forecasts for Canadian corn production and consumption levels in 1990 and placed them into the simulation model. Then we subjected the model to shocks which would approximate the probable impacts of ethanol plants with 50,000 and 500,000 tonnes corn intake capacity. The results of these simulations are presented in Tables 2.A and 2.B..

TABLE 2.A AN ASSESSMENT OF THE LIKELY IMPACT OF ETHANOL PRODUCTION INITIATIVES ON THE ONTARIO CORN MARKET IN 1990

Approximate Total Capacity Intake (000 tonnes)	0	50		500	
Value of Z	1.00 (Baserun)	0.99		0.91	
- Levels (numbers in parentheses are percentage change from the Baserun) -					
Variable[a,b]					
De	1668	1667	(-0.03)	1663	(-0.32)
Do	5033	5083	(0.98)	5516	(9.58)
Du	139927	139904	(-0.02)	139704	(-0.16)
Ie	686	686	(-0.09)	679	(-0.99)
K	61100	61100	(0.00)	61100	(0.00)
Pe	142.09	142.18	(0.07)	143.11	(0.72)
Po	134.44	134.54	(0.08)	135.52	(0.81)
Pu	145.19	145.25	(0.04)	145.77	(0.40)
Se	982	982	(0.01)	983	(0.14)
So	6668	6670	(0.02)	6682	(0.20)
Su	200078	200103	(0.01)	200317	(0.12)
Xk	200	200	(0.00)	200	(0.00)
Xo	1634	1587	(-2.95)	1166	(-28.68)

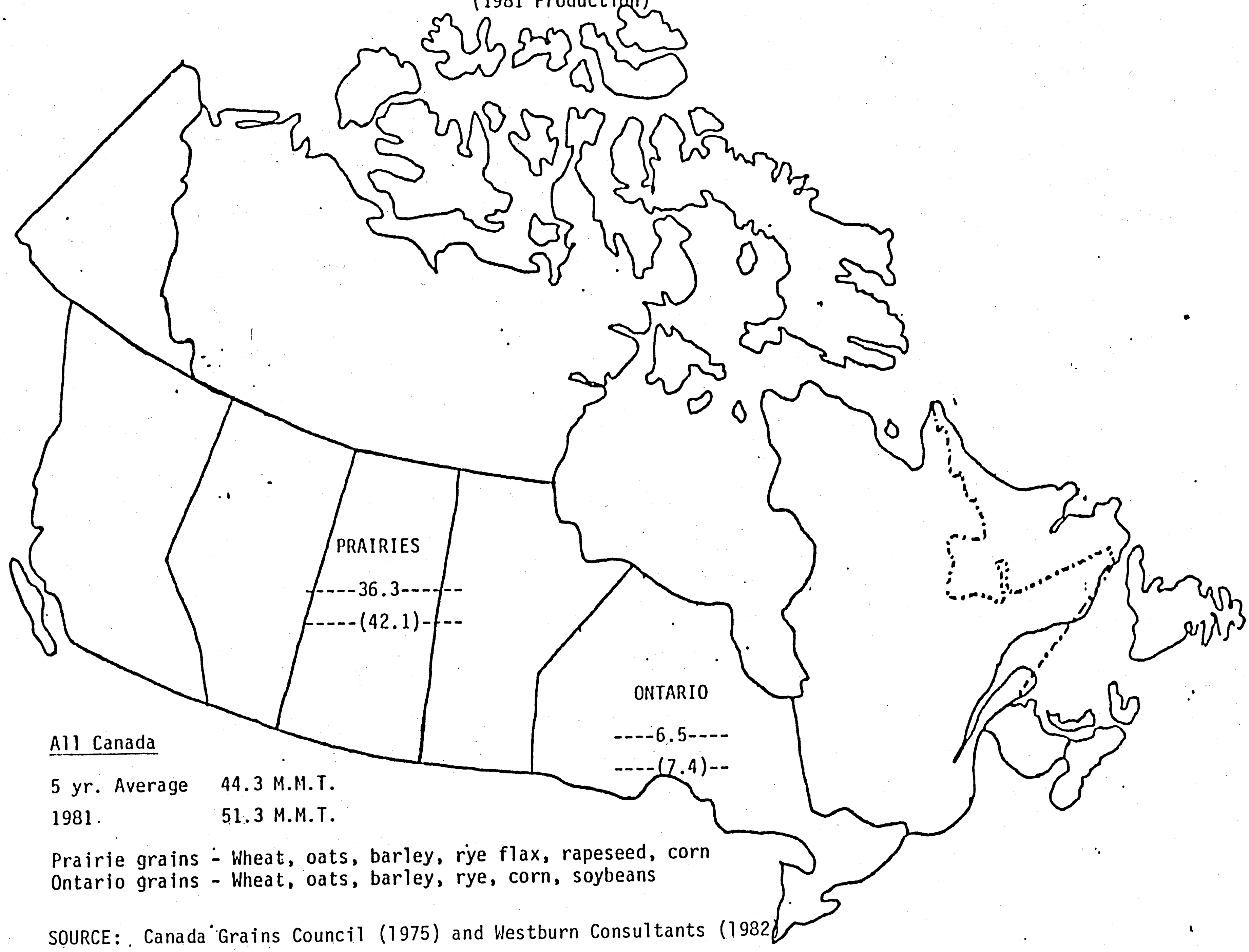
[a]All prices are in the $C/metric tone; all quantities are in thousands of metric tonnes.

[b]Parameters used are estimates selected from Meilke (1984, p. 9 and p. 88) and Krakar (1985, Tables 3 through 9). Parameter values selected for a, b, c, d, e, f, g, and Xk were -0.35, 0.25, -0.45, 0.20, -0.4, -0.3, 0.011 and 200 respectively.

TABLE 2.B POTENTIAL ONTARIO CORN MARKET IMPACTS OF A 500,000 TONNE EFFECTIVE DEMAND INCREASE: A COMPARISON BETWEEN THE PRESENT AND 1990

Variable	Present Status Quo	Present With shock	Present % change With shock	1990 Status Quo	1990 With shock	1990 % change with shock
De	1,400	1,383	-1.21	1,668	1,663	-0.32
Do	4,600	4,945	7.49	5,033	5,516	9.58
Du	140,000	139,900	-0.07	139,927	139,704	-0.16
Je	1,000	981	-1.91	686	679	-0.99
K	59,400	59,400	-	61,100	61,100	-
Pc	155.84	160.11	2.74	142.09	143.11	0.72
Po	137.02	150.60	9.92	134.44	135.52	0.81
Pu	145.00	145.26	0.18	145.19	145.77	0.40
Sc	400	402	0.54	982	983	0.14
So	5,000	5,120	2.39	6,668	6,682	0.20
Su	200,000	200,107	0.05	200,078	200,317	0.12
Xk	200	200	-	200	200	-
Xo	400	175	-56.29	1,634	1,166	-28.68

FIGURE 9. 5 YEAR AVERAGE PRODUCTION (1977-81) MILLIONS OF METRIC TONNES
(1981 Production)



All Canada

5 yr. Average 44.3 M.M.T.

1981 51.3 M.M.T.

Prairie grains - Wheat, oats, barley, rye flax, rapeseed, corn
Ontario grains - Wheat, oats, barley, rye, corn, soybeans

SOURCE: Canada Grains Council (1975) and Westburn Consultants (1982)

An examination of Table 2 indicates that the 50,000 tonne capacity plant would have a negligible impact on corn prices in Southern Ontario in 1990. Plants with total capacity summing to 500,000 tonnes would probably result in price increases of less than one percent in the year 1990. Hence, we are reasonably safe in our assessment that Ontario corn market prices in the year 1990 would not be significantly altered by relatively large investments in ethanol production.

At present, however, the corn market may only take initiatives with a total corn intake capacity of up to 200,000 tonnes before serious impact on domestic corn prices may occur. For this reason, it would be wise to approach these ethanol production initiatives in a step-wise fashion to ensure the solvency of ethanol plants using corn feedstocks; capacities should be expanded incrementally in tandem with growth in the Ontario corn industry.

Much the same type of analysis could be conducted for barley and other potential feedstocks in Western Canada. Intuitively, it is anticipated that the effects of such initiatives into the production of ethanol would not have the same magnitude of market impacts and distorting effects in Western Canada as in Ontario and other regions of Eastern Canada. The reasons behind this conjecture are: first, the relative size of the markets in question (the prairies have a larger supply base, Figure 9); second, the potential for the substitution of alternative feedstocks for ethanol production is greater on the prairies and, third, the price determination process for Western Canadian agricultural feedstocks occurs, for the most part, outside of Canada's borders.

5. SPINOFF EFFECTS: THE DISTILLERS DRIED GRAIN, SOYBEAN AND SOYBEAN MEAL MARKETS

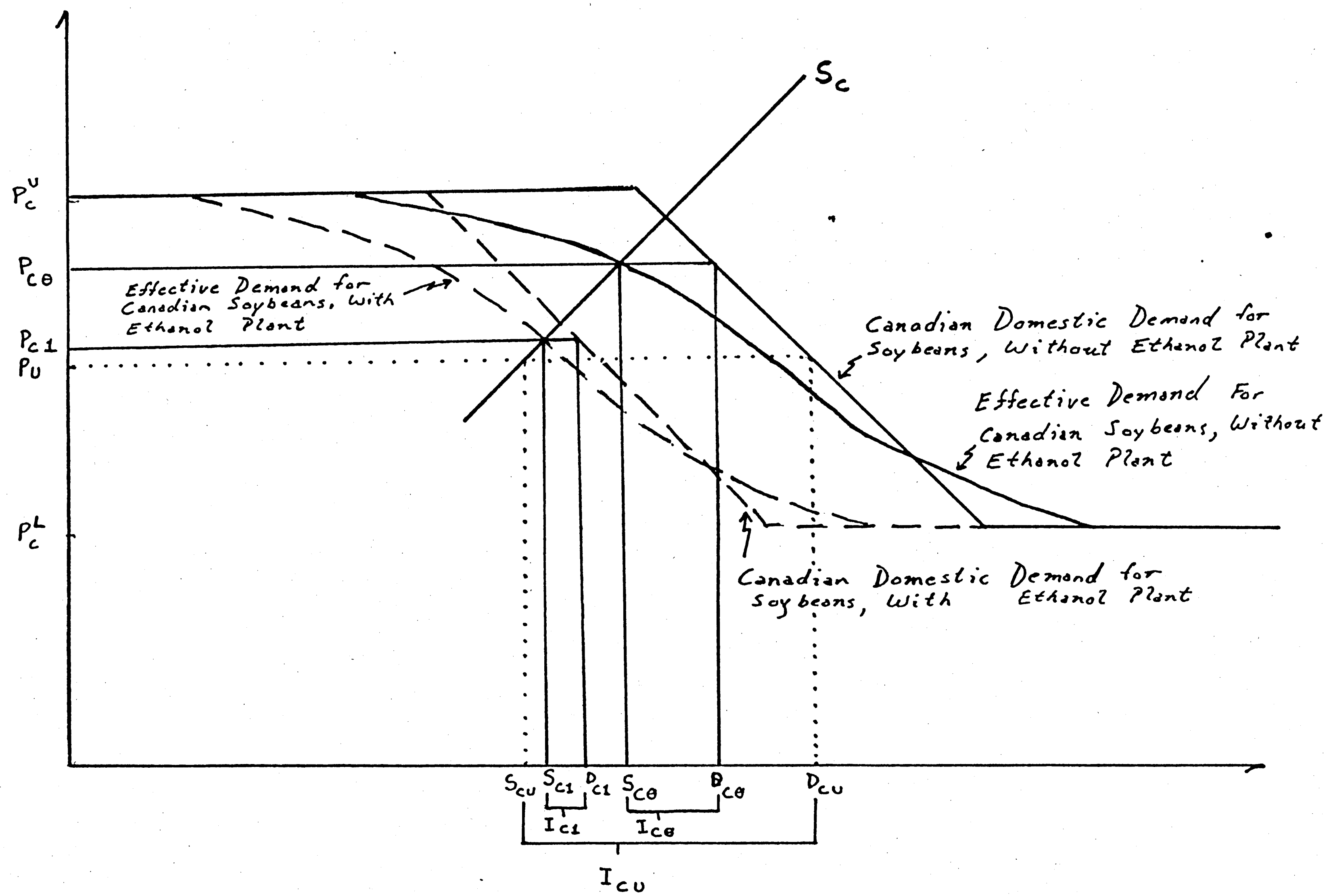
One of the by-products of ethanol production from grain corn is dry distiller's grain (DDG), which can be used in animal feed mixes. Its relatively high protein content make it a reasonable substitute for soybean meal in some hog and cattle rations. However, it has a relatively high fibre content and, consequently, cannot be used extensively in poultry rations. Using the technical process proposed, we would anticipate a yield of one metric tonne DDG per three metric tonnes of corn used (Wardrop et al). Actual data regarding the energy and protein content of corn, soybean meal and DDG are contained in Appendix 2.

Based on the available data from the 1982 census of the Alcoholic Beverage Industries, shipments of DDGs from manufacturers amounted to 109,220 tonnes in Canada; no breakdown is available for Ontario. Despite the lack of market information, we can affirm that a potential increase in supplies of 16,700 tonnes from a small plant of 50,000 tonnes, corn feedstock capacity is significant and that the potential increase of 167,000 tonnes from a larger initiative of 500,000 tonnes corn intake capacity is enormous.

For a plant of significant size, it is conceivable that the sale of DDG for use in livestock feeds would have a depressing effect on "local" soybean prices through its competition with soybean meal as a component in livestock feed rations. If the plant handles 500,000 tonnes of corn annually, about 167,000 tonnes of DDG by-product will be yielded. It is assumed that this would have a feed value of approximately 125,000 tonnes of soybean meal (see appendix 2). Chattin and Doering (1984) and Beaulieu and Goodyear (1985) used more sophisticated techniques to establish the relative feed value of DDGs but, for the purposes of this study, this assumption provides us with an adequate proxy.

In figure 10, we have tried to capture the spatial nature of the arbitrage process as well as the potential impacts that the proposed ethanol plant would have on the 'local' soybean market. If the marketplace and trade between countries were perfectly frictionless (no transportation or transaction costs), then P_u would prevail and Canada would produce S_{cu} and import the difference between D_{cu} and S_{cu} to satisfy demand. However, we know that the soybean market is not frictionless and that Canada's domestic market is insulated to some degree by the existance of transportation and other costs. If there were a physical barrier between Canada and the U.S., then the Canadian market would operate and respond solely to domestic market conditions between the price boundaries established by P_u plus or minus transaction costs (P_c^U, P_c^L). However, the Canadian market is not geographically separated from the

FIGURE 10. POTENTIAL IMPACTS OF A NEW ETHANOL PLANT ON THE ONTARIO SOYBEAN MARKET



American market and, consequently, is not insulated to the same degree; we have specified a smooth, switching logarithm function to capture the relationship. This model predicts that price P_{c0} would prevail on the domestic market, while Canadian production would be S_{c0} and consumption D_{c0}, with the difference being made up with imports. By releasing the ethanol production by-product on the market, domestic demand for soybeans is likely to be depressed somewhat because of the opportunities to substitute DDGs for soybeans. Price P_{c1} would prevail while Canadian producers would supply S_{c1} and consumers would demand D_{c1}, with the difference being made up with imports.

We constructed a small, two region model which provides a simple characterization of the North American soybean industry in an effort to obtain more precision in our assessment of the kind of impacts we can expect the ethanol plant(s) to have on the soybean industry. The soybean model is as follows:

Soybean demand relationships:

$$D_c = \alpha_o \cdot P_c^{\alpha_1} / Z \qquad (1)$$

$$D_u = \delta_o \cdot P_u^{\delta_1} \qquad (2)$$

Soybean supply relationships:

$$S_c = \beta_o \cdot P_c^{\beta_1} \qquad (3)$$

$$S_u = \gamma_o \cdot P_u^{\gamma_1} \qquad (4)$$

Soybean price linkage equation:

$$P_c = P_u + \tau_1 \cdot \ln (I_c - I_k) \text{ if } I_c \quad l_k + 2.7 \qquad (5a)$$

$$= P_u - \tau_1 \cdot \ln (I_k - I_c) \text{ if } I_c \quad I_k - 2.7 \qquad (5b)$$

$$= P_u + (\tau_1/2.7)\ (I_c - I_k) \text{ otherwise} \qquad (5c)$$

Soybean identities:

$$D_c + D_u = S_c + S_u - k \quad (6)$$

$$I_c = D_c - S_c \quad (7)$$

D_c is Canadian demand in 000 tonnes
D_u is American demand in 000 tonnes
S_c is Canadian supply in 000 tonnes
S_u is American supply in 000 tonnes
P_c is the Canadian (Chatham) price in \$C/mt
P_u is the American (Chicago) price in \$C/mt
I_c is the level of Canadian imports in 000 tonnes
I_k is the import level at which the price linkage equation has its inflection point and was obtained by conducting a grid search and subjectively assessing whether the results were consistent with the limited data available.
K is the North American level of exports.
Z parameter used to subject the model to demand shocks
$\alpha_0, \alpha_1, \delta_0, \delta_1, B_0, B_1, \gamma_0, \gamma_1, \Upsilon_1$ are the parameters

Equations (5a), (5b), and (5c) are mathematical expressions which combine to approximate the 'Effective Demand for Canadian Soybeans' curve illustrated in figure 9.

Once again, we have specified a switching logarithm function for the relationship between the Chatham and Chicago prices (of soybeans) in order to capture the spatial nature of the arbitrage process and the fact that producers are located between Chicago and Chatham (Figure 9). Since there exists a broad range of estimated elasticities of supply and demand for soybeans in the literature, we have constructed tables which reflect higher and lower values in the range for both the small plant and the large plants. (Meilke and Griffith, p. 38 and p. 44 and pp. 17-26).

For the "small" plant (50,000 tonne corn intake capacity), the potential impacts of the DDG by-product on the soybean market would not be large. For both the low and the high elasticity scenarious, prices would fall one percent or less. Imports of soybeans would fall approximately 2 percent under the low elasticity scenario, and approximately 1.5 percent under the high elasticity scenario.

The impacts of the "large" plant (500,000 tonnes corn intake capacity) would be more substantial. Under the low elasticity scenario, prices would fall by more than 6 percent while imports would fall approximately 25 percent. Under the high elasticity scenario, prices would fall by more

TABLE 2.A POTENTIAL IMPACTS OF CHANGES IN EFFECTIVE DEMAND FOR SOYBEANS DUE TO AVAILABLE DDG SUPPLIES FROM ETHANOL PRODUCTION
- LEVELS -

	Low elasticities[a]			High elasticities[a]		
Variable[b]	Base run	Small plant	Large plant	Base run	Small plant	Large plant
D_c	1,074	1,066	979	1,074	1,067	1,001
D_u	18,519	18,521	18,554	18,519	18,521	18,544
S_c	764	762	749	764	762	742
S_u	29,478	28,475	29,435	29,478	29,476	29,453
I_c	310	304	231	310	305	260
P_c	300	297	280	300	298	283
P_u	294	294	293	294	294	293

TABLE 2.B POTENTIAL IMPACTS OF CHANGES IN EFFECTIVE DEMAND FOR SOYBEANS DUE TO AVAILABLE DDG SUPPLIES FROM ETHANOL PRODUCTION
- PERCENTAGE CHANGE FROM BASE RUN -

	Low elasticities[a]		High elasticities[a]	
Variable	Small plant	Large plant	Small plant	Large plant
Dc	-0.81	-8.84	-0.67	-6.75
Du	0.02	0.20	0.01	0.14
Sc	-0.30	-2.05	-0.33	-2.94
Sv	-0.01	-0.15	-0.01	-0.08
Ic	-2.04	-25.60	-1.52	-16.14
Pc	-1.01	-6.66	-0.67	-5.80
Pv	-0.04	-0.49	-0.02	-0.17

We have assumed:[a]

Low elasticities	High elasticities
$\alpha_1 = \delta_1 = -0.4$	$\alpha_1 = \delta_1 = -0.8$
$B_1 = \gamma_1 = 0.3$	$B_1 = \gamma_1 = 0.5$
$I_k = 300$, $\rho_1 = 2.845$	$I_k = 300$, $\rho_1 = 2.845$

a Once again, the range of relevant elasticities can be found in Meilke (1984), Meilke and Griffith (1982) and Krakar (1985). Meilke and Griffith have a particularly good review of findings in the empirical literature (pp. 17-46, especially p. 38 and p. 44).

b Prices are expressed in $C/tonne while quantities are in thousands of metric tonnes.

than 5 percent while imports would fall by 16 percent. Once again, these prices impacts will be softened to some extent by the fact that the soybean market is not self-enclosed; it interacts with the markets for other oilseeds such as canola. Nevertheless, transportation costs may provide a sufficient degree of insulation to allow a large portion of these price and quantity adjustments to occur. Such a depression of soybean prices may not have serious implications for farmers in most of Ontario, but it would significantly affect farmers living in counties (such as Kent and Essex) in the extreme southwestern corner of Ontario where soybeans are a major crop.

In western Canada, the by-products from ethanol production initiatives utlizing western barley would compete directly with canola meal. One would not, however, anticipate substantial price impacts on the domestic canola market for modest ventures into ethanol production in Western Canada. Once again, this is because of the large supply base and export orientation of the grains and oilseeds industry in Western Canada (Figure 9).

Another aspect of marketing the by-products of ethanol production is the fact that ethanol firms may have to undercut the market in the short term in order to establish a market niche and gain a clientele. Such a venture may also require some extension and information related expenditures to educate farmers in the use of the high protein by-products of ethanol production. These costs must also be considered when calculating the set up costs of such a venture.

6. SPINOFF EFFECTS: THE GRAIN CORN PROCESSING INDUSTRY

Meilke (1984) made a number of observations regarding the 1983 utilization of processing capacity in the grain corn processing industry and they still seem fairly valid today:

> There was ... a general consensus that 85 percent utilization based on 330 work days would represent a good level of capacity utilization ... the industry was operating somewhat below the 85 percent utilization rate in 1983, perhaps in the range of 65 to 75 percent of capacity.
>
> The distilling industry is running well below capacity with a utilization rate of 46 percent in 1982 and an estimated utilization rate of 42 percent for 1983 (Meilke, 1984, p. 70).

The grain corn processing industry utilizes the same type of agricultural feedstocks that would be used by new ethanol production initiatives. Furthermore, the by-products (DDG's) from the proposed ethanol production initiatives would compete directly with the by-products from the present corn processing industry. Given the present over-capacity in the grain processing industry and their generally unfavourable financial position, governments must be extremely cautious when assisting initiatives which compete for the same inputs and in many of the same by-products markets. That is, when extending assistance to a 'developing industry' such as the ethanol industry, governments must ensure that their actions (through their effects on prices in particular) are not undermining the viability of the existing industry; otherwise, one may simply be shifting resources from firms and industries that have demonstrated their ability to survive to those that have not, while having no substantial affect an overall processing capacity (and, by implication, effective demand). This provides another good reason why public or private investors making expenditures in ethanol production would be wise to begin with modest ventures (totalling 200,000 tonnes corn intake capacity or less) and expand this capacity in concert with growth in the Ontario corn industry.

7. SPINOFF EFFECTS: LIVESTOCK INDUSTRY

It is sufficient to say that any increase in the price of corn will be detrimental to Ontario's livestock industry while lower soybean and distiller's grain prices will be of some benefit. The net effect of such an ethanol plant (or collection of plants) would be to disadvantage most Ontario livestock producers, although by 1990 the impact will not be substancial.

8. SPINOFF EFFECTS: EASTERN CANADA

Feedstock prices in eastern Canadian markets will not be affected to the extent that local Ontario prices would be due to the buffering effects of competition from Western Canadian barley and American corn and soybeans. Nevertheless, we would expect some price impact, perhaps of one-quarter to one-third of the size of the "local" Ontario price impact, depending on the actual elasticities of supply and demand prevailing in eastern markets as well as their degree of self-sufficiency.

9. OTHER FACTORS WORTHY OF CONSIDERATION

Ethanol production initiatives would probably make domestic demand less seasonal. Ethanol plants would demand corn throughout much of the year and, consequently, would tend to "deseasonalize" prices to some extent even if they do not result in general price enhancement. Farmers, naturally, would welcome any initiative which will have a stabilizing influence on the markets in which they deal.

The simulation results presented in this paper represent upper bounds to the likely market impacts of ethanol production initiatives. The partial equilibrium approach employed here naturally precludes some moderating factors. For example, the comparative static results have been derived by making the ceteris parabus assumption and treating the corn and soybean market complexes as separate entities. Furthermore, we have imposed a rather rigid marginal rate of substitution between distillers grains and soybeans. Chattin and Doering (1984) employed a linear programming model for least-cost feed formulation in order to provide a more realistic representation of the trade-offs that could occur in the demand between corn by-products and other feed ingredients. Their results indicated that studies which preclude the use of corn by-products as replacements for other low-protein feeds and feedgrains tend to overestimate market impacts to some extent. The extent to which these factors will have a moderating influence will be determined by the market saturation levels for the various by-products.[9]

Still on the subject of the shortcomings of partial equilibrium results, the supply-side analysis has been conducted under the assumption that prices for other competing production (supply-side) alternatives remain unchanged; yet, by the very nature of the ethanol production process, concurrent changes in market structure occur in both the corn and soybean market complexes. Once again, this indicates that the actual market price impacts will be slightly more moderate than the partial equilibrium comparative static results obtained here would indicate.

Ethanol production from agricultural feedstocks is already becoming an area of government intervention abroad and these government policies will, in all probability, play a key role in determining the market orientation of any developing ethanol industry. After the 1974 disruption of oil supplies, Brazil was the first country to turn to agricultural biomass as a major substitute for petroleum. Brazil's foreign exchange was (and is) scarce and credit for petroleum imports was (and is) limited. Furthermore, Brazil is the world's largest sugarcane producer, making a large supply of renewable feedstock readily available. Loans for ethanol production investment are available at below market rates and significant price supports are in place in the Brazilian sugarcane industry (Gill and Allen, 1985). With sugar prices at historical lows, additional sugar exports need to be subsidized and are not profitable; as long as the losses from ethanol exports are less than those from sugar exports, the incentive remains to channel as much cane as possible into ethanol and export it instead of sugar (Gill and Allen, 1985).

The European Economic Community (EEC) is the largest foreign market for gluten and distillers' feeds. Currently, by-product feeds are exempt from the duties imposed on other agricultural imports by the EEC (Chattin and Doering, 1984). However, the possibility of duties on by-product feeds is being discussed and recent GATT sessions indicate a restrictive mood in the EEC (Gill and Allen, 1985). Naturally, the imposition of tariffs on gluten and distillers' products would reduce the potential international market for these by-product feeds. The EEC has also been exploring the potential for ethanol production from current stockpiles of whey, sugarbeets and cereals. While such undertakings would require some subsidization, that seldom seems to be a significant inhibiting factor with the EEC.

The United States has also demonstrated an increasing willingness to subsidize and protect their domestic ethanol industry. The federal and state governments has provided several incentives such as gasoline tax exemption, investment credits, income tax credits, sales tax exemptions, and loan guarantees for fuels utilizing a specified proportion of alcohol. Tariffs have also been levied against Brazilian ethanol exports.

Obviously, the domestic tariff and trade policies of Brazil, the EEC and the United States will play a major role in determining the market outlook for both ethanol and its by-products. Consequently, these policies are quite key to determining the solvency of Canadian ethanol production initiatives and will directly impinge on any expansion strategies for the Canadian industry.

10. CONCLUSION

Given the present degree of market insulation and relative price levels in Canada and the United States, an ethanol plant with a 500,000 tonne corn capacity (or a number of smaller plants with the same capacity) located in Southern Ontario would have a significant impact on the "local" Ontario market. The price of corn in Chatham could, conceivably, rise by 10 percent while the price for soybeans could decline by as much as 5 percent; this latter assessment is probable reflective of the price impact one could also anticipate for the by-product of ethanol production, distiller's dried grains. **Although these impacts may represent a 'worst case' scenario, these potential price impacts should be incorporated into any assessment of the potential revenue flows to and from an ethanol plant and will seriously impinge on any assessment of such a plant's solvency. The detrimental price impacts will diminish as Ontario's surplus trade position increases; if present production trends continue, Ontario's trade position in 1990 will be such that ethanol production initiatives of the magnitude examined here will not have serious 'local' market price impacts. For these reasons, we recommend that any initiatives (whether public or private) into ethanol production begin at a modest level (200,000 tonnes corn intake or less) and expand incrementally in tandem with growth in the Ontario corn industry.**

Firms wishing to invest in ethanol production do have some options available to them with which they can buffer the impacts they have on the markets for agricultural feedstocks. They can locate themselves close to the United States border and in those Ontario corn producing areas of greatest concentration to minimize their relative share of a geographic market and take advantage of supplies from a number of sources. They can also integrate more with the primary sector in order to dampen the price depressing effects that they have on the markets for their by-products. This could either be accomplished by contracting with local livestock feeders regarding the sale and disposal of by-products or, perhaps, by engaging in livestock production themselves. This may also help to alleviate marketing problems associated with the short storage life of some of the by-products.

What much of this discussion comes down to is, essentially, a requirement for geographic separation and market spreading to avoid adverse market impacts. Whether the 500,000 tonne corn capacity is one huge plant or several smaller plants makes little difference to the potential market impact if they are all located in a relatively small geographic area and compete for the same inputs and in the same output and by-product markets. It is probable that firms looking into the potential for ethanol production from Southern Ontario corn need not concern themselves with market impacts if the possible total capacity intake of the firms producing ethanol is small relative to the size of the corn industry (say 200,000 tonnes or less). However, if they suspect that plans for expansion are at the larger end of the spectrum examined in this paper, the potential for changes in relative prices of inputs and outputs is quite substantial and must be considered when assessing such projects' profit potential.

The precise location of a plant could prove to be quite critical to its competitive position. For this reason, we suggest that further research efforts should focus on the evaluation of the potential viability of plants in specific locations. In terms of establishing possible plant sites one could use criteria such as the proximity to major corn producing areas, proximity to major cattle and pork producing areas (for disposal of DDG by-product), proximity to the petroleum industry, availability of suitable storage facilities for agricultural feedstocks, proximity to port facilities and, perhaps, the availability of low cost power sources. A short list of potential sites could include locations such as Chatham, Goderich, Sarnia, St.Thomas/Port Stanley and Woodstock. Such a study could establish the competitive position of a plant located in one town in Southern Ontario relative to another town in Southern Ontario. The next step would involve comparing the competitive position of the most viable ethanol plant location in Southern Ontario with the competition from

American and Brazilian ethanol sources, as well as the competition from octane enhancers which are not of agricultural origin.

Firms in western Canada may have fewer problems with regard to 'local' market impact because of the high volumes moved and exported; the price formation process for prairie cereals is fairly independent of Canadian demand (and, therefore, ethanol production initiatives). Nevertheless, such conjectures should not replace rigourous analysis; similar analysis should be conducted for the prairie provinces if assessments of the potential for ethanol production initiatives to be viable are to be trustworthy.

Finally, we must remind the reader that, although the parameters used in this analysis are those commonly found in the agricultural economic literature, the judgement used and specifications chosen may be subject to some debate. For this reason, we once again refer the reader to Appendix 1.

FOOTNOTES

1. This discussion draws a great deal on Bressler and King (1970).

2. Canada's tariff on grain corn was $3.15 Canadian per metric tonne until January 1, 1980 when a phase reduction to $1.97 Canadian per metric tonne ($C/mt) began. Canadian tariff rates for the upcoming years are: 1985 - 2.28 $C/mt, 1986 - 2.13 $C/mt and 1987 - 1.97 $C/mt. In return for the reduction in the Canadian tariff the United States is reducing its tariff on grain corn from $9.84 American per metric tonne to $1.97 American per metric tonne ($A/mt) over the same period. Using a 1.3 Canada/U.S. exchange rate, we can express the American upcoming tariff rates for corn in Canadian dollar equivalents: 1985 - 5.12 $C/mt, 1986 - 3.84 $C/mt, and 1987 - 2.56 $C/mt. A crude estimate of the cost of handling and transporting corn between Chatham and Chicago would be between 13.00 $C/mt and 16.50 $C/mt. The actual exchange rate at the time of writing was 1.3702.

   If present tariff and transportation cost regimes continue, Canadian prices will depend, at least in part, on local conditions when the Canadian price either does not exceed the Chicago Canadian equivalent price plus transportation and Canadian tariffs (a differential of about 18.50 $C/mt beyond 1987) or is no less than the Chicago Canadian equivalent price less transportation and American tariffs in Canadian equivalents (a differential of about 19.00 $C/mt beyond 1987). Hence, it can be stated that any initiative which diverts a significant portion of Canadian production will have an effect on "local" prices up until the point where profitable arbitrage would occur between the Chicago and Chatham markets. As an example, one could examine the price relationship which prevailed through the month of August 1985 and determine the degree to which "local" prices can change due to altered domestic conditions. The prevailing prices at that time were 151.51 $C/mt and 142.03 $C/mt in Chicago and Chatham respectively. Presuming that the price is "set" in

Chicago, local (Chatham) prices may fall by as much as 8.52 \$C/mt or rise by as much as 28.01 \$C/mt before significant arbitrage between the markets would place a floor or a ceiling on price movements in the local market (Figure 6).

3. It is questionable whether the Canada/U.S. price relationship is actually as symmetrical as the characterization provided in this paper. Although it is conceivable that, if Canada became a significant net exporter of corn, corn would be exported to the north eastern United States, it is more likely that the corn would be sent to either the EEC or the eastern block countries. For this reason, the price linkage specification may not be adequate for objectives or extreme bound analysis outside that of the present analysis.

4. It is important to note the placement of the curve 'Effective Demand Forced by Ontario Producers' in Figure 6. If the producing regions were clearly demarked by international boundaries, the curve would intersect the Ontario Demand Curve at point C. However, it is clear that international boundaries do not demarcate the producing areas (Figure 3), and that the Chicago and Chatham market centres both transmit farmgate isoprice contours (Figure 5) between which the farmer must choose. Consequently, it would only be a coincidence if the curve 'Effective Demand Faced by Ontario Producers' in Figure 6 actually did pass through point C.

5. see Footnote 3

6. Equations (7a), (7b) and (7c) are conditional statements which combine to approximate the 'Effective Demand Faced by Ontario Producers' curve shown in Figures 6 through 8. Equations (7a) and (7b) represent the presumed symmetrical relationship between the direction and volume of trade and the Chicago-Chatham basis. Equation (7c) is, essentially, a splicing equation which deals with the problem of taking logarithms of numbers less than 1. We chose the 'cut off' valves for the logarithmic expressions of $X_k \pm 2.7$ to facilitate the model's convergence. The algorithm used to solve the model works in a step-wise fashion and, if the value selected had been 1.0 instead of 2.7, the solution values for P_o and P_u would not change

over successive iterations over the range $X_k - 1.0$ to $X_k + 1.0$ and, therefore, the simulation model would be unable to come to a successful convergence. We selected the value 2.7 for several reasons, the first being ease of computation; the natural logarithm of 2.7 is approximately 1. This value is also superior to 1.0 in that it enables us to more closely approximate the smooth transition phase discussed earlier in the paper.

7. Eastern imports are thought to be the sum of exports from Ontario and import levels from the U.S.. Hence, we presume that the prevailing price in the east (Montreal) will be an appropriately weighted average of prices in Chatham and Chicago, plus transportation and transaction costs. Expressed algebraically,

$$P_e = \alpha . P_o + (1-\alpha) P_u + T$$

where: $\alpha = X_o / I_e$

$$(1-\alpha) = (I_e - X_o) / I_e$$

which, after substitution and simplification, yields (8c). Obviously, the assumptions implicit in equations (7a) through (8c) are fairly restrictive, but they do capture the flavour of the basic pricing mechanisms involved in the corn market complex.

8. The expression (Ie/Dc). 2.845 ln (Ie) at the front of equations (8a), (8b) and (8c) represents the amount by which the quoted eastern (Montreal) price will differ from the quoted Chatham and Chicago prices. Its formulation is based upon a number of observations:

(i) Transportation and other transaction costs increase at a decreasing rate with larger volumes and greater distances. This general relationship is approximated by the expression in 'ln(Ie)'.

(ii) Agents must be reasonably sure of recouping their transportation and transaction costs before they will ship to a particular destination. The figure 2.845 is simply the figure which, when multiplied by the logarithm of all of the east's consumption, yields a number which reflects transportation and transaction costs quoted for Chatham/Chicago shipments to Montreal. This is based on the simple premise that, if the eastern provinces imported all of their consumption requirements, prices in Montreal would exactly reflect those in Chatham and Chicago plus the cost of transfer.

(iii)There is some competition between 'local' eastern production and imports from the United States and Ontario. This competition effectively places an upper bound on the Montreal basis vis-à-vis Chicago and Chatham. For this reason, we have included the term (Ie/De) which reflects that proportion of consumption in the eastern provinces which is made up of shipments from other sources.

9. Beaulieu and Goodyear (1985) employed similar techniques to those of Chattin and Doering (1984) and obtained results which are consistent with the latters' findings.

REFERENCES

Beaulieu, Y. and T. Goodyear (1985) Potential for Ethanol Production from Agricultural Feedstocks for use in Alcohol-Gasoline Blends, Working Paper, Regional Development Branch, Agriculture Canada, December.

Bressler, R.G. and R.A. King (1970) Market, Prices and Interregional Trade, John Wiley & Sons, Inc., New York.

Canada Grains Council (1975). Grain Handling and Transportation, Winnipeg.

Chapman, J.D. and Sherman, J.C. (1967). Oxford Region Economic Atlas: United States and Canada, Clarendon Press, Oxford.

Chattin, B. and O.C. Doering, III (1984), 'An Alcohol Fuels Programme: Will it Solve Surplus Grain Production?' Food Policy, February.

Gill, M. and E. Allen (1985) 'States of the U.S. Ethanol Market', Feed: Outlook and Situation Report, U.S.D.A., Washington, August.

Griffith, G.R. and Meilke, K.D. (1982) A Structural Econometric Model of the World Markets for Rapeseed, Soybeans and their Products, School of Agricultural Economics and Extension Education, Publication AEEE/82/5, O.A.C., University of Guelph, Guelph.

Griffith, G.R. and Meilke, K.D. (1980) A Description of the Market Structure and Agricultural Policies in Five Regional Oilseed and Oilseed Product Markets, School of Agricultural Economics and Extension Education, Publication AEEE/82/5, O.A.C., University of Guelph, Guelph.

Groenewegen, J.R. (1984), 'Appendix: Exchange Rates and Grain Prices', Market Commentary, Agriculture Canada, Ottawa, June.

Groenewegen, J.R. (1984), 'The Canadian Coarse Grains Industry', Economic Working Papers, Agriculture Canada, Ottawa.

Groenewegen, J.R. (1976), Forecasting the Ontario Corn Basis to Reduce Hedging Risk, M.Sc. Thesis, University of Guelph.

Hardey, E., member for Kent (1985) 'Energy: Advisability of Production and Distribution of Octane Enhancers', Hansard-Private Members Business, Ottawa, October 15, pp. 7659-7662.

Hasnain, S.ed. (1984), Fifth Canadian Bioenergy R&D Seminar, Elsevier Applied Science Publishers, New York.

Hill, L.D., Leath, M.N. and S.W. Fuller (1978). Corn Movements in the United States, Illinois Bulletin 768, Agricultural Experimental Station, University of Illinois at Urbane-Champaign.

Krakar, E. (1985), Food and Agriculture Regional Model, Grain and Oilseed Component*, Unpublished Agriculture Canada working paper.

Martin, L. and K.D. Meilke (1985). Effect of an Increase in Demand on the Ontario Corn Basis, Department of Agricultural Economics and Extension Education, University of Guelph.

Meilke, K.D. (1984), An Economic Profile of the Ontario Grain Corn Industry, School of Agricultural Economics and Extension Education, Publication AEEE/84/8, O.A.C., University of Guelph, Guelph.

Paddock, B. and Daoust, A. (1985), Personal Communication.

Paul, J.K., ed (1980) Large and Small Scale Ethyl Alcohol Manufacturing Processes from Agricultural Raw Materials, Noyes Data Corporation, New Jersey.

Smith, B. (1985) Presentation to the Fuel Ethanol Workshop Held at Agriculture Canada's Central Experimental Farm, St. Lawrence Reactors Ltd.

Transport Canada (1985) The Role of Trucking in the Grain Industry, Ottawa, February.

Wardrop, W.L., and Associates (1985), Preparation of an Economic Model for the Production of Liquid Fuels from Agricultural Biomass, Agriculture Canada ERDAF Program, Ottawa.

Westburn Consultants (1982) Towards a More Efficient Handling and Transportation System in Ontario, Winnipeg, February.

APPENDIX 1. IMPACT ANALYSIS AND LONG TERM FORECASTING: A CAUTIONARY NOTE

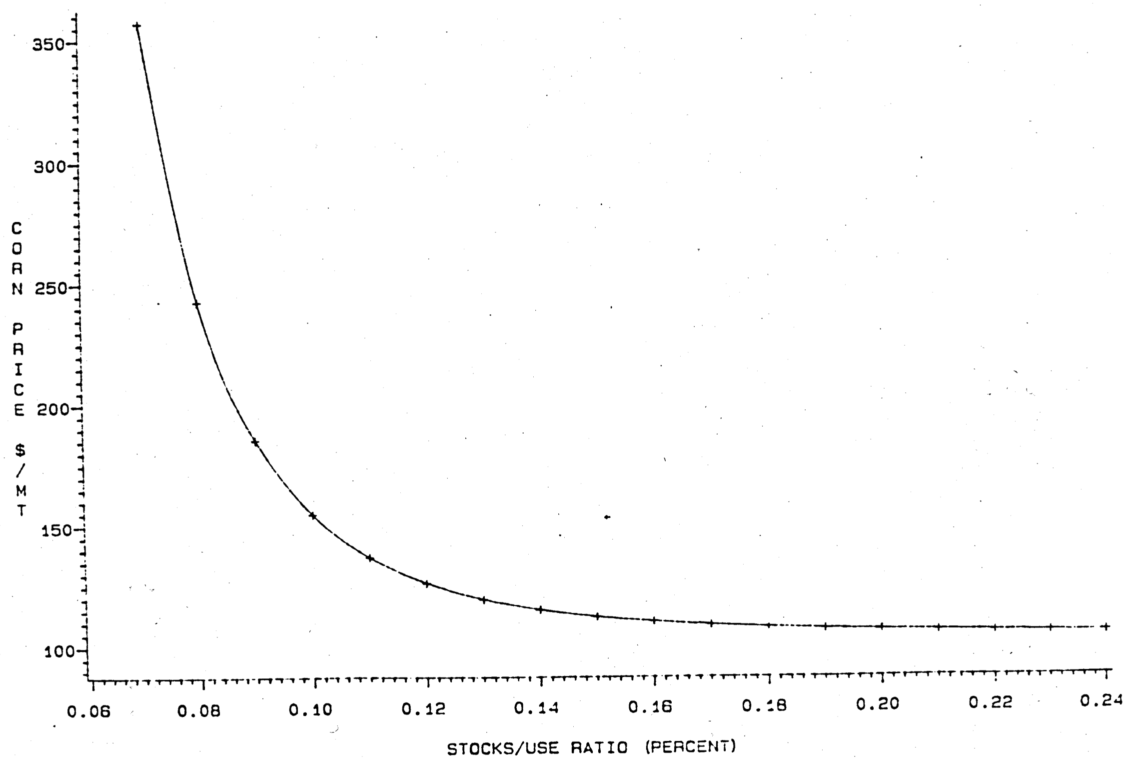
A truly rigorous assessment of this type of investment opportunity obviously requires some long-term forecasts with regard to output, input and capital markets. Several attempts to forecast the long-run demand for grain products have been made in the past and, almost invariably, researchers have projected a continuation of economic conditions as they existed at the time. These assumptions were almost invariably violated; long-term forecasting is a hazardous task at best and impossible at worst. Our problem of assessment is compounded because an initiative of the magnitude proposed will alter the very structure of the industry. We, like most of our predecessors, must rely on the assumption that, for the most part, present trends and conditions will continue. We have, however, identified a few relationships in the text of this paper which do allow us to anticipate where changes are likely to occur and what the ramifications of those changes are likely to be. To serve as a caution to anyone who may wish to treat the analysis contained hererin as absolute, we shall proceed with some passages which indicate that the difference between scarcity and surplus in the world's corn market is a 'knife's edge', and how this makes for difficult forecasting.

Corn prices are extremely difficult to anticipate, partially as a result of the fine line between "scarcity" and "surplus" in the world's grain markets (Meilke, 1984). Since the early 1960's, corn prices have been predominantly influenced by (1) supply and demand conditions and (2) the United States loan rate. Meilke (1984, p. 110) examined this relationship and his findings are summarized in part by figure A.1 in which the relationship between market prices and the stock/utilization-ration (with the 1982 loan rate of $104.32 per metric tonne) is illustrated.

For stock/utilization ratios above 17 percent market prices are very close to the loan rate, and production and demand changes have little impact on price. For example, a change in stock/utilization ratio from 0.20 to 0.17 would raise the annual average price by only $2.37 per metric tonne or 2.2 percent. In contrast, changes in the stock/utilization ratio below 0.17 have a much greater impact on price; for example, a decline in the stock/utilization ration from 0.14 to 0.11 raises prices by $21.55 per metric tonne or 18.7 percent. Consequently, changes in stock/utilization ratio, as small as three or four percentage points, can result in vastly different prices, and price changes. The line between scarcity and surplus in the coarse grain market is a thin one indeed (Meilke, 1984, p. 110).

These observations indicate that any point forecast must be treated with extreme caution. It is probably best to rely on a combination of "average" and "worst case scenario" forecasts before drawing inferences.

FIG. A.1: RELATIONSHIP BETWEEN THE STOCKS/USE RATIO AND CORN PRICE.



Source: Meilke, 1984, p.111

APPENDIX 2. A COMPONENT PRICING DERIVATION FOR DRY DISTILLERS GRAIN

It is the purpose of this appendix to establish a reasonable estimate for the likely price for the by-product from the ethanol-production-from-corn process, dry distillers grain (DDG). We shall do this by 1) estimating the unmeasured value for energy and protein based on current quarter prices for corn and soybeans and 2) using these estimated prices and the known and relatively fixed proportion of energy and protein found in DDG to obtain a 'market' price estimate for DDG under present conditions (August 1985).

A.2 Step 1:

Required Information

P^*_S = the price of Soybean meal = 221.00 \$ C/mt (Toronto)

P^*_C = the price of Corn = 130.33 \$ C/mt (Chatham)

There 3,696 kilocalories and 3,916 kilocalories of energy in one metric tonne of soybean meal and corn respectively. Soybean meal and corn possess 0.44 and 0.10 tonnes of protein per tonne respectively. We can express these relationships algebraically and solve for the prices of energy and protein:

$$0.44\ P_p + 3{,}696\ P_e = P^*_S \qquad (1a)$$

$$0.10\ P_p + 3{,}916\ P_e = P^*_c \qquad (1b)$$

where: P_p is the estimated price of protein

P_e is the estimated price of energy

From (1a) and (1b) one obtains:

$$P_p = (1.0595P^*_S - P^*_C)\ /\ 0.3662 \qquad (2a)$$

$$P_e = (4.400\ P^*_C - P^*_S)\ /\ 13534.4 \qquad (2b)$$

A.2 Step 2

Required information

We have the estimated price relationships for energy and protein from above. One tonne of DDG contains 0.27 tonnes of protein and 3696 kilocalories of energy. We can use this information to derive a formula for the anticipated price for the DDG:

$$P^*_{DDG} = 0.27\ P^*_p + 3696\ P_e$$

$$= 0.27\ (1.0595\ P^*_S - P^*_C)\ /\ 0.3662 +$$

$$3696\ (4.400\ P^*_C - P^*_S)\ /\ 13534.4$$

which gives:

$$P^*_{DDG} = 0.5081\ P^*_S + 0.4643\ P^*_C$$

and, given current prices for corn and soybean meal:

$$P^*_{DDG} = 174.32\ \$\ C/mt$$

Since DDG is relatively high in fibre (and, therefore, less suitable for poultry feed mixes) a crude estimate of its value as a feedstuff would be about 165.00 \$ C/mt, given current market conditions. Given the $P^*_{DDG}\ /\ P^*_S$ ratio, we assume that the DDG are equivalent to 75 percent of Soybean meal on a nutrition / mass basis.

APPENDIX 3. SENSITIVITY ANALYSIS OF THE IMPACT OF CHANGING THE SELECTED 'SWITCHING LEVEL' IN THE PRICE LINKAGE EQUATION

In this appendix we examine the sensitivity of prices, production, consumption and export levels to the selected 'switching export level' in the price linkage equation of our corn market model. We present the results of our simulations for the 'base run' and for the large ethanol plant effective 'demand shock' given switching export level values (Xk) of -1000, -500, -100 and 300 thousand tonnes in addition to the text specification selected and the baserun. All other assumptions are consistent with those described in the text.

Over the five years 1980-84 we have observed the general levels for the following variables:

(A.1) $D_o=4600 \quad S_o=5000 \quad X_o=S_o-D_o=400 \quad P_o=137.00 \quad P_u=145.00$

In keeping with our depiction of the "switching" nature of the function relating 'local' Ontario corn prices (Chatham) to the world, or American, corn prices (Chicago), we postulated the following relationship.

$$\text{(A.2)}\quad P_o=P_u \;/\; (1 + (\text{IF } X_o \quad X_k + 2.7 \quad \text{THEN } G1 \,.\, \text{LOG } (X_o - X_k)$$
$$\text{ELSE } (\text{IF } X_o \quad X_k - 2.7 \quad \text{THEN } -G1 \,.\, \text{LOG } (X_k - X_o)$$
$$\text{ELSE } (G1 \;/\; 2.7) \,.\, (X_o - X_k)))$$

Given the values observed in (A.1) we notice that it is the first part of the 'conditional' statement in (A.2) that is most relevant in the baserun. We can manipulate (A.2) until it is in a form that we can solve for the product of $G1.LOG(X_o-X_k)$. Algebraically:

(A.3) $(P_u / P_o) - 1 = G1 . LOG (X_o - X_k)$

Which, given the observations in (A.1), gives:

$0.0583 = G1 . LOG (400 - X_k)$

THIS CAN BE SATISFIED WHEN:

Level of exports at which the switching function has its inflection point (X_k) equals:	Coefficient of the switching function (G1) equals:
-1000	0.0081
.	.
.	.
.	.
-500	0.0086
.	.
.	.
.	.
-200	0.0091
-100	0.0094
0	0.0097
100	0.0102
200	0.0110
300	0.0127

Obviously, it is important to determine how robust our analysis is should we have erronously selected our 'representative' switching export level (X_k=200) and coefficient (G1=0.0110). The sensitivity analysis is presented in Tables A.1 and A.2.

TABLE A.1 ASSESSING THE IMPACT OF AN EFFECTIVE (500,000 TONNE) DEMAND SHIFT USING DIFFERENT 'SWITCHING EXPORT LEVEL' AND COEFFICIENT VALUES

	Shock impact (on levels) with: Alternative Specifications				Selected specification	No shock
Value of Xk	-1000	-500	-100	300	200	BASE-
Value of Gl	0.0081	0.0086	0.0094	0.0127	0.011	RUN
Value of Z	0.90	0.90	0.90	0.90	0.90	1.00
Variable						
De	1 385	1 385	1 385	1380	1383	1400
Do	3 098	5 093	5 070	4 913	4 945	4 600
Du	139 772	139 776	139 795	139 929	139 900	140 000
Ie	984	984	984	977	981	1000
K	59 400	59 400	59 400	59 400	59 400	59 400
Pe	150.50	150.50	150.50	161.00	160.11	155.84
Po	138.02	138.40	140.18	153.43	150.60	137.02
Pu	145.59	145.58	145.53	145.18	145.26	145.00
Se	402	402	402	402	402	400
So	5 009	5 013	5 029	5 144	5 120	5 000
Su	200 244	200 240	200 220	200 075	200 107	200 000
Xo	-89	-81	-42	231	175	400

TABLE A.2 PERCENTAGE CHANGE FROM THE BASERUN WITH AN EFFECTIVE DEMAND SHIFT USING DIFFERENT 'SWITCHING' EXPORT LEVELS'

	Shock impact (in percentage) with: Alternative Specifications				Selected specification
Value of Xk	-1000	-500	-100	300	200
Value of Gl	0.0081	0.0086	0.0094	0.0127	0.011
Value of Z	0.90	0.90	0.90	0.90	0.90
Variable					
De	-1.04	-1.04	-1.04	-1.45	-1.21
So	10.83	10.71	10.22	6.79	7.49
Du	-0.16	-0.16	-0.15	-0.05	-0.07
Ie	-1.64	-1.64	-1.64	-2.30	-1.91
K	-	-	-	-	-
Pe	2.35	2.35	2.35	3.31	2.74
Po	0.74	1.03	2.32	12.00	9.92
Pu	0.41	0.40	0.37	0.13	0.18
Se	0.47	0.47	0.47	0.65	0.54
So	0.18	0.26	0.57	2.87	2.39
Su	0.12	0.12	0.11	0.04	0.05
Xo	-122.22	-120.20	-110.46	-42.21	-56.29

It seems that altering the 'switching export level' (XK) and its associated parameter (G1) does significantly affect the assessment of 'local' Ontario market impacts, price impacts in particular. Ontario price impacts range from 0.74 percent with a selected switching export level of -1000 (i.e. 1 million tonnes of corn imports) to 12.00 percent with a selected switching export level of 300 (i.e. 300,000 tonnes exported). It is our assessment that the behaviour of the market price over the last five years (given Canada's trading position) is most consistent with a switching export level of 200, although no rigourous statistical tests could be conducted due to an insufficient number of data points. In the selected scenario the price change due to a 500,000 tonne demand shift would be 9.92 percent.

Given the absence of data with which to reconcile these conjectures, we must remind the reader that the functional specification outlined in this paper has been selected in an *ad hoc* fashion. For this reason, all estimates contained herein should be interpreted as fairly general rather than precise estimates. That is, the effects on the present local southern Ontario market of a 500,000 tonne corn/ethanol plant are likely to be substantial while the effects on the eastern (Montreal) market will be significant, but less substantial. There will be little effect on the American market.

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