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THE PRICE AND ECONOMIC IMPACT OF THE WALHALLA ETHANOL PLANT ON THE NORTH DAKOTA ECONOMY

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Preface

The work upon which this report is based was partially supported by funds from the Agricultural Products Utilization Commission. This research project was intended to accomplish two objectives. First, the research estimated the impact that Dawn Enterprises' entry into the barley market had on the price of barley; secondly, the economic impact and contribution associated with the plant's operation were determined. Several methodologies were employed to estimate the price impacts resulting from the opening of a new market for North Dakota barley. The North Dakota Input-Output model was used to estimate the economic impact and contribution (i.e., personal income, retail trade activity, total business activity) associated with the plant's operation in 1986.

The authors wish to express their appreciation to Dr. F. Larry Leistritz, Dr. Thor A Hertsgaard, Dr. Donald F. Scott, Mr. Dan Zink, and Ms. Brenda Ekstrom for their review of this manuscript. The authors also would like to acknowledge Ms. Shelly Swandal for typing this report, Ms. Carol VavRosky for preparing the figures, and the various faculty members of the Department of Agricultural Economics for their reviews and suggestions. Finally, we express our thanks to Mr. Bob Thornberg of Dawn Enterprises and the staff of Agweek magazine for providing data essential for this analysis.

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Highlights

North Dakota's first ethanol plant became operational in mid-1985, a time of high stocks of North Dakota barley. This plant offered a potential market for 6 million bushels of barley when production of ethanol reached its capacity of 11 million gallons per year. Operation of the plant does have an economic impact in the state, and several methodologies were tried to determine if the Walhalla ethanol plant's entry into the barley market had an impact on barley prices.

Price impacts were analyzed using terminal-local market price spreads, local market price comparisons, statistical models, and an elasticity model. Terminal-local market price spreads had mean differences that were statistically significant for pre- and post-Dawn existence for Duluth, but not for the Pacific Northwest markets. This would indicate a price impact, but the significant decline in barley shipments to Duluth indicates that market may not have been the price basis for the 1985-1986 crop year. Sufficient and accurate data were not available to estimate price impacts using the local market price comparison methodology. Statistical models were developed to estimate the barley price relationship between terminal and local markets for pre-and post-Dawn time periods. Dummy slope and intercept terms were incorporated into this relationship to determine if a price impact existed and its magnitude. The Duluth market showed a statistically significant price impact; however, the price impact varied from positive to negative over the range of prices that existed during the analysis period. An elasticity of demand approach estimated the price impact to be in a range of $.009 to $.004. Price impacts were estimated for two sets of eleasticities because of the widespread difference of opinion concerning elasticity values for the North Dakota barley market.

Economic impacts associated with the operation of the Walhalla ethanol plant were estimated using the North Dakota input-output model. Local impact expenditures (the firm's additional expenditures to the economy) amount to almost $6 million and generated $5.4 million in personal income, $3.7 million in retail trade activity, and a total business activity of $16.2 million. Contribution expenditures, or the firm's total, were about $13 million for the same period and produced personal income of $12.4 million, $9.5 million in retail trade activity, and $42.8 million of total business activity. Estimated tax collections associated with the plant's operation impact and contribution expenditures amounted to $292,000 and $701,000, respectively. The plant employs 70 direct workers with another 277 indirect and induced jobs created by operating expenditures, while contribution expenditures created 641 secondary jobs. For each dollar the plant spends in the state another $1.81 is generated through the multiplier process for a total of $2.81. Contribution expenditures created an additional $2.29 of business activity for each dollar spent giving a total of $3.29.

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Introduction

North Dakota's first commercial ethanol plant, located near Walhalla, became operational in 1985. This facility has the capacity to use 6 million bushels of barley a year and produce 11 million gallons of ethanol. The Walhalla ethanol plant differs from most others in the United States in that it uses barley rather than corn to produce ethanol. Introduction of this plant offered North Dakota barley growers another market for their product. The impact this facility has on the state is two-fold: first, the increased demand for local barley may cause the price to rise; and secondly, the injection of local operating expenditures will create an economic impact. These two types of impacts will be analyzed in this study to determine their existence and magnitude.

Acres planted to barley (3.5 million) in North Dakota in 1985 were second only to spring wheat (5.9 million) (North Dakota Agricultural Statistics 1986). Production of barley was estimated to be 175,950,000 bushels in 1986 and 184,250,000 in 1985--the largest and second largest production of the crop in recent history (North Dakota Agricultural Statistics Service 1986a; North Dakota Agricultural Statistics Service 1986b). Current federal farm program provisions (i.e., deficiency payment, loan rate, etc.) have made raising barley an attractive crop alternative for North Dakota farmers because the provisions offer a form of price protection for barley acreages in the program. The resulting production, coupled with lower prices and lack of markets, have resulted in huge surpluses of barley in the state. The need for additional markets to consume the surplus barley is obvious, and plants to convert the grain into ethanol offer a market within the state. Ethanol production at Walhalla in 1986 could possibly convert 6 million bushels of barley into consumable fuel. Removing this amount of barley from storage is actually disposing of only a small portion of the 1986 production, and thus, has resulted in questions whether the Walhalla plant has had a significant impact on barley prices in the state or local region. This report describes several methods undertaken to analyze the pertinent prices and markets and to determine if the usage of barley by the plant has had a price impact and, if so, the magnitude.

Operation of the ethanol plant at Walhalla does have an impact on the state's economy. New and additional expenditures for operation of the plant are injected into the economy and, as a result of the multiplier process, higher levels of total business activity, retail trade, and personal income occur. In addition, secondary impacts, such as indirect and induced employment and tax revenues, accrue within the state. Similar analyses have been performed for many plants and industries in North Dakota; for example, the lignite industry (Coon and Leistritz 1986), the potato industry (Coon, Leistritz, and Scott 1986), the recreation industry (Mittleider and Leitch

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1984), a livestock slaughter plant (Wulff, Petry, Helgeson, and Coon 1986), the North Dakota State University (Coon, Leistritz, and Hertsgaard 1986), and agriculture (Coon, Vocke, and Leistritz 1984) have all been recently analyzed to determine their effects on the state's economy. Measuring, in terms of economic variables, the Walhalla ethanol plant's impact on the economy of North Dakota provides an indication of the importance of the industry to the state's economy.

The Ethanol Industry

The ethanol industry is rather new to North Dakota as well as to the United States, with its development occurring since the late 1970s. Ethanol production in the nation has grown from 40 million gallons in 1980 to 650 million gallons in 1985, about a 16-fold increase (Table 1). The industry arose out of the world oil problems that existed in the 1970s. Production of ethanol from renewable feedstocks appeared to be the common solution to several problems: (1) it could reduce the dependence on foreign oil, (2) it

TABLE 1. ETHANOL PRODUCTION BY STATE, 1980 TO 1985

State	1980	1981	1982	1983	1984	1985
	million gallons					
Illinois	28	56	123	205	196	350
Indiana	--	--	--	--	2	41
Iowa	--	3	52	61	70	70
Kansas	1	5	3	3	11	5
Kentucky	--	--	2	13	18	18
Louisiana	--	--	--	--	12	20
Nebraska	--	--	--	--	2	8
Ohio	--	--	2	35	52	55
Virginia	--	--	--	--	--	15
Tennessee	--	--	8	40	38	33
Other States	11	11	20	18	29	35
Total	40	75	210	375	430	650

SOURCE: Zink 1986.

could be used as an octane-enhancer to replace lead in unleaded gasoline in accordance with federal lead reduction regulations (Economic Research Service 1985), and (3) it could reduce commodity surpluses and thereby reduce federal government farm program payments and storage costs while increasing the prices for farmers.

Development of the Ethanol Industry

The use of alcohol as a fuel is not new and, in fact, dates back to the first modern internal combustion engine, the Otto Cycle in 1876 (Gavett, Grinnell, and Smith 1986). Because of the cost and availability of oil, alcohol never became a principal fuel source. However, because of oil embargoes, disrupted oil supplies, and unprecedented oil price increases during the 1970s, the federal government encouraged "energy independence" through the increased production of domestic energy sources. Domestic oil production increased in response to price increases, and alternative energy sources such as solar power and ethanol production from renewable sources became potential solutions to the energy problem.

Federal government legislation provided the impetus for development of nonpetroleum energy alternatives through a variety of grants, guaranteed loans, tax incentives, etc. Several pieces of legislation were critical to the development of the ethanol industry (Gavett, Grinnell, and Smith 1986). The Food and Agriculture Act of 1977 (P.L. 95-113) authorized loan guarantees of up to $15 million each for four biomass (ethanol from vegetative material) pilot plants. The financing was to be administered by the Farmers Home Administration with Commodity Credit Corporation funding authority. Also, the law expanded the general agricultural research authority of USDA to include energy-related research and set up a competitive grant program for energy-related research into substitutes for nonrenewable fuels, petrochemicals, and industrial hydrocarbons. The Energy Tax Act of 1978 (P.L. 95-618) exempted fuel containing at least 10 percent alcohol (by volume) from the $0.04-per-gallon federal gasoline excise tax through October 1, 1984. A 10 percent energy investment tax credit (EITC) was granted for equipment to convert biomass into alcohol using a primary energy source other than oil, natural gas, or their derivatives. Federal gasoline excise tax exemptions for ethanol were extended to December 31, 1992 and the EITC was extended through December 31, 1985 by The Crude Oil Windfall Profit Tax Act of 1980 (P.L. 96-223).

The Energy Security Act of 1980 (P.L. 96-294) provided several key provisions affecting the ethanol industry. Insured loans of up to $1 million for small-scale biomass energy programs (less than 1 million gallons per year of ethanol) were authorized as were loan guarantees to cover up to 90 percent of construction costs for such projects. Also, the Office of Alcohol Fuels in the Department of Energy was established under this law. The Consolidated Farm and Rural Development Act of 1980 (P.L. 96-438) authorized the Farmers Home Administration to guarantee loans for alcohol production facilities under the Business and Industry Loan Program. The Surface Transportation Assistance Act of 1982 (P.L. 97-424) increased the Federal gasoline excise tax to $0.09 per gallon and increased the alcohol-blended fuel exemption to $0.05 per gallon effective April 1, 1983.

North Dakota Ethanol Industry

North Dakota's ethanol industry currently consists of two facilities. A plant with an annual capacity to produce 11 million gallons of ethanol annually is located at Walhalla and owned by Dawn Enterprises, and a second plant with a 4.5 million annual capacity is owned and operated by Alchem Inc. at Grafton (Figure 1). Dawn Enterprises plant became operational in mid-1985, and the Alchem Inc. facility began producing ethanol in early 1986. The analysis in this report is only for the Walhalla plant because of its longer operational period. Data for Alchem, which was in operation only a few months at the time this study was initiated, would not be sufficient to perform either a price or economic impact assessment.

The ethanol plant at Walhalla primarily uses barley as its feedstock although some corn has been used to facilitate the grinding process. Barley yields 1.8 gallons of ethanol per bushel, slightly less than corn (2.5 gallons per bushel). North Dakota barley production has increased significantly in recent years and is expected to reach its largest level of production in recent years in 1986. This level of production would indicate that sufficient stocks of barley are available in the state to provide feedstocks for the ethanol plants (Table 2). Corn production has followed a trend similar to that of barley with the 1986 production projected to be the largest in recent years.

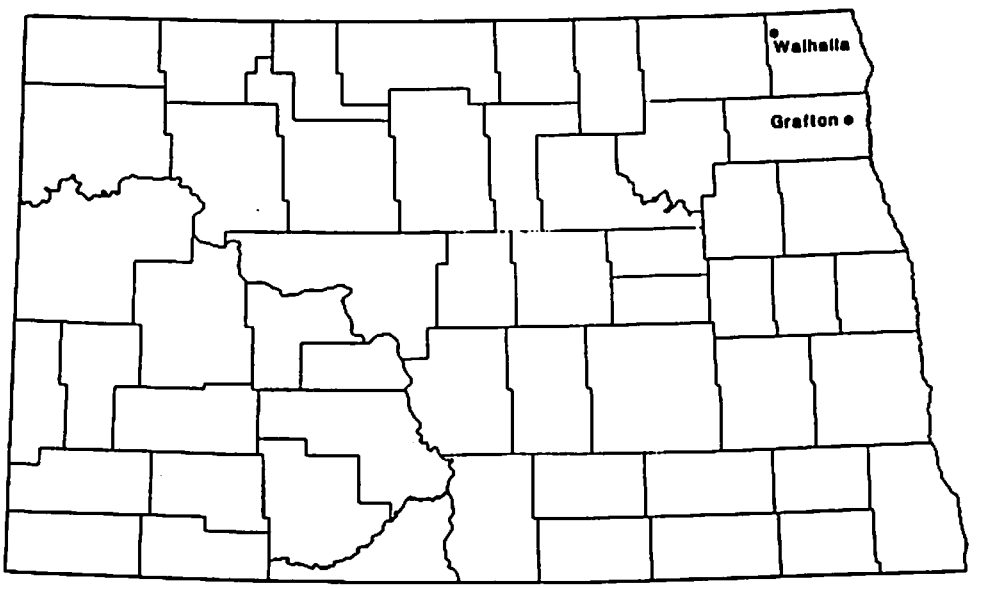

Figure 1. Location of Commercial Ethanol-Producing Plants In North Dakota, 1986

TABLE 2. NORTH DAKOTA PRODUCTION OF BARLEY AND CORN, 1980 TO 1986

Year	Production	
	Barley	Corn Grain
	million bushels	
1980	48.0	16.8
1981	100.8	41.6
1982	103.4	35.4
1983	114.7	29.1
1984	153.7	41.6
1985	184.3	40.3
1986[a]	176.0	48.0

[a]Preliminary estimate.

SOURCES: North Dakota Agricultural Statistics Service 1986b; North Dakota Agricultural Statistics Service 1986a.

Locations of the ethanol producing facilities in Walhalla (Pembina County) and Grafton (Walsh County) are well situated in relation to barley production in North Dakota. Pembina County (8th in barley production) and Walsh County (9th in barley production) are also in close proximity to the second- (Cavalier County) and third-leading (Grand Forks County) barley producing counties in the state (Figure 2). Barley production is concentrated in the northern and central Red River Valley, indicating that the locations of the plants would be in areas where ample supplies of barley would be available for a feedstock.

Production of ethanol has increased since the first month of operation (July 1985) to over 900,000 gallons in July of 1986 (Table 3). July 1986 production was essentially at full capacity, and continued production at that rate for 12 months would produce 10.8 million gallons of ethanol with plant capacity rated at 11 million gallons. In addition to the production of ethanol, two by-products result during the process: distillers dried grains and solubles (DDGS) and carbon dioxide. Because of a lack of a market for the carbon dioxide, it is not recovered during the manufacturing process. However, DDGS are an important part of the manufacturing process because they can be sold as a high protein livestock feed supplement. Approximately 20 pounds of DDGS is produced for each bushel of barley consumed in the manufacturing process. DDGS production at the Walhalla plant was over 3,400 tons in July of 1986, slightly lower than the peak achieved earlier (Table 3).

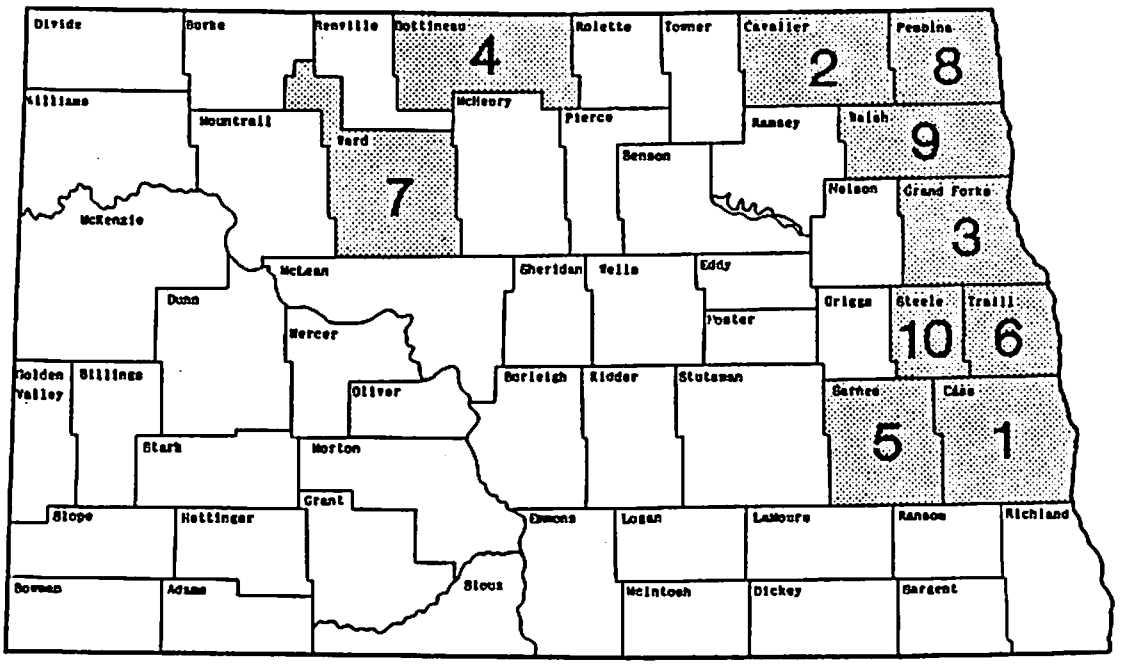

Figure 2. Location and Ranking of Leading Barley-Producing Counties in North Dakota

About one half of the DDGS production at the Walhalla plant is shipped to the export market (principally to Europe), and the remaining half goes to dairy and feedlot operations, primarily in the western United States.

Price Impact Analysis

Determining the existence and magnitude of a price impact associated with the entry of the Walhalla ethanol plant into the barley market was one purpose of this study. Several methods were employed to determine the price impact: terminal-local market price spreads, local market price comparisons, statistical models, and an elasticity model. Each of these methodologies could provide an independent estimate of the price impact and, therefore, all are included in this report. Data requirements and level of sophistication varies greatly among the methods, but each is based on economic principles and could provide interesting and useful results. The conceptual framework and the associated results for each methodology employed will be discussed in the sections that follow.

TABLE 3. PRODUCTION OF ETHANOL AND DISTILLERS DRIED GRAINS AND SOLUBLES (DDGS) AT THE WALHALLA PLANT, JULY 1985 TO 1986

Month/Year	Ethanol	DDGS
	- gallons -	- tons -
1985		
July	692,822	--
August	420,252	--
September	399,263	1,637
October	591,329	4,070
November	621,685	4,070
December	781,572	3,136
1986		
January	750,895	3,485
February	636,710	2,915
March	570,223	2,163
April	881,008	3,491
May	688,454	3,102
June	877,038	3,649
July	903,314	3,407

SOURCE: Thornberg 1986.

Terminal-Local Market Spreads

The first attempt to determine if a price impact existed was an analysis of the Duluth and Pacific Northwest terminal market and local market price spreads for barley. Duluth #2 feed barley (Agweek 1985-1986) and Pacific Northwest (PNW) #2 feed barley (Agricultural Marketing Service 1985-1986) prices for the January 1985 to May 1986 period were available and aggregated to a monthly level. Published local elevator board prices also were available by town for selected North Dakota and Minnesota locations. The Agweek magazine published "Local Grain Prices" on a weekly basis and was determined to be the best available source of local elevator prices.

Published weekly prices were the high and low prices from Friday to Friday based on a daily telephone survey of local elevators. Price data were available for the period January 1, 1985 through July 31, 1986 from this source. Published prices were board prices and provided no indication of whether any grain was purchased at the given price. Sixteen towns were selected from the published list to represent local markets that were varying distances from the Walhalla ethanol plant (Table 4).

TABLE 4. ROAD MILES TO WALHALLA, NORTH DAKOTA FROM SIXTEEN SELECTED TOWNS IN NORTH DAKOTA AND MINNESOTA

Town	Distance to Walhalla, ND
	-------- miles ---------
Crystal	35
Devils Lake	100
Ellendale	252
Forest River	80
Gwinner	215
Harvey	183
Hunter	161
Jamestown	199
Langdon	31
Larimore	89
McVille	101
Rugby	140
Thompson	130
Valley City	168
West Fargo	193
Hallock, MN	46

Terminal-local market price spreads were calculated for each of the 16 towns for each month for the January 1985 to May 1986 period. This represents 6 months prior to and 11 months after the opening of the Walhalla ethanol plant. These spreads are presented for the Duluth market and the Pacific Northwest market in Tables 5 and 6, respectively. A situation where the mean pre-Dawn (pre-Dawn refers to the period before the Dawn Enterprises plant was operational and post-Dawn is used to indicate the period after the plant became operational) margin was greater than the mean post-Dawn margin, and statistically significant, could indicate a price impact. A change in mean margins for the pre- and post-Dawn periods does not conclusively indicate a price impact as the result of the plant's operation. Numerous other factors may have contributed, or even caused the margins to change during the period of the analysis. Therefore, the market situation must be evaluated before drawing conclusions.

TABLE 5. DIFFERENCE BETWEEN DULUTH AND LOCAL MONTHLY AVERAGE PRICE FOR FEED BARLEY AT SIXTEEN SELECTED TOWNS IN NORTH DAKOTA AND MINNESOTA, JANUARY 1985 TO MAY 1986

Town	1985												1986				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	dollars																
Crystal	.41	.34	.37	.42	.46	.42	.27	.20	.26	.19	.11	.11	.12	.03	-.19	-.06	.14
Devils Lake	--	--	--	--	--	--	--	.30	.30	.22	.17	.13	.07	-.01	-.19	-.07	.18
Ellendale	--	--	--	--	--	--	--	--	--	.24	.24	.19	.10	.00	-.24	-.13	.14
Forest River	.47	.40	.43	.48	.52	.45	.28	.38	.37	.28	.23	.18	.11	-.01	-.20	-.10	.17
Gwinner	--	--	--	--	--	--	--	--	.29	.24	.31	.18	.07	-.10	-.27	-.18	-.02
Harvey	.38	.36	.44	.48	.59	.53	.36	.22	.28	.22	.10	.12	.07	-.12	-.25	-.08	.18
Hunter	.44	.29	.34	.37	.39	.34	.29	.28	.23	.23	.25	.27	.10	.01	-.33	-.24	.12
Jamestown	.41	.37	.45	.44	.50	.42	.29	.15	.13	.10	.08	.05	.03	-.05	-.27	-.13	.11
Langdon	.43	.35	.45	.51	.53	.49	.34	.19	.28	.21	.15	.14	.11	.00	-.16	-.07	.15
Larimore	.43	.36	--	.43	.47	.41	.31	.30	.31	.19	.12	.11	.08	.00	-.19	-.08	.14
McVille	.43	.39	.42	.43	.50	.44	.36	.30	.32	.24	.21	.15	.09	.01	-.17	-.09	.17
Rugby	--	--	--	--	--	--	--	.26	.22	.19	.21	.11	.03	-.07	-.25	-.09	.14
Thompson	.42	.36	.36	.39	.40	.30	.29	.32	.30	.27	.19	.15	.12	.03	-.15	-.02	.24
Valley City	.39	.33	.38	.42	.48	.42	.38	.22	.18	.22	.16	.12	.08	.04	-.15	-.03	.19
West Fargo	.40	.34	.37	.40	.41	.34	.28	.24	.18	--	.12	.18	.15	-.01	-.15	-.02	.23
Hallock, MN	.48	.41	.47	.44	.49	.45	.36	.33	.40	.44	.41	.35	.19	.01	-.13	-.03	.19

Note: Difference was calculated as Duluth price minus local price, therefore, a negative value would indicate the local price was above the price at Duluth.

TABLE 6. DIFFERENCE BETWEEN PACIFIC NORTHWEST AND LOCAL MONTHLY AVERAGE PRICE FOR FEED BARLEY AT SIXTEEN SELECTED TOWNS IN NORTH DAKOTA AND MINNESOTA, JANUARY 1985 TO MAY 1986

Town	1985												1986				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	dollars																
Crystal	.77	.75	.70	.67	.71	.74	.72	.68	.69	.76	.74	.79	.76	.69	.62	.69	.80
Devils Lake	--	--	--	--	--	--	--	.78	.73	.79	.80	.81	.71	.65	.62	.68	.84
Ellendale	--	--	--	--	--	--	--	--	--	.81	.87	.87	.74	.66	.57	.62	.80
Forest River	.83	.81	.76	.73	.77	.77	.73	.86	.80	.85	.86	.86	.75	.65	.61	.65	.83
Gwinner	--	--	--	--	--	--	--	--	.72	.81	.94	.86	.71	.56	.54	.57	.64
Harvey	.74	.77	.77	.73	.84	.85	.81	.70	.71	.79	.73	.80	.71	.54	.56	.67	.84
Hunter	.80	.70	.67	.62	.64	.66	.74	.76	.66	.80	.88	.95	.74	.67	.48	.51	.78
Jamestown	.77	.78	.78	.69	.75	.74	.74	.63	.56	.67	.71	.73	.67	.61	.54	.62	.77
Langdon	.79	.76	.78	.76	.78	.81	.79	.67	.71	.78	.78	.82	.75	.66	.65	.68	.81
Larimore	.79	.77	--	.68	.72	.73	.76	.78	.74	.76	.75	.79	.72	.66	.62	.67	.80
McVille	.79	.80	.75	.68	.75	.76	.81	.78	.75	.81	.84	.83	.73	.67	.64	.66	.83
Rugby	--	--	--	--	--	--	.--	.74	.65	.76	.84	.79	.67	.59	.56	.66	.80
Thompson	.78	.77	.69	.64	.65	.62	.74	.80	.73	.84	.82	.83	.76	.69	.66	.73	.90
Valley City	.75	.74	.71	.67	.73	.74	.83	.70	.61	.79	.79	.80	.72	.70	.66	.72	.85
West Fargo	.76	.75	.70	.65	.66	.66	.73	.72	.61	--	.75	.86	.79	.65	.66	.73	.89
Hallock, MN	.84	.82	.80	.69	.74	.77	.81	.81	.83	1.01	1.04	1.03	.83	.67	.68	.72	.85

Note: Difference was calculated as Pacific Northwest minus local price.

Duluth market margin means were $.42 and $.12 pre- and post-Dawn (Table 7). This would imply a $.30 price impact that was statistically significant, but the results of the Pacific Northwest market were not consistent with these findings as the pre-Dawn and post-Dawn price spreads were not significantly different. An explanation for this difference of results is the shift in barley movements to major markets. A decline from 25 percent of the 1984 crop to 8 percent of the 1985 crop has occurred in barley movements to Duluth (Table 8). During this time, shipments to the Midland and Southwest (which use a Pacific Northwest price base) increased from 6 to 22 percent of the total. This situation indicates the Duluth market has become less of a factor in the pricing of North Dakota barley. Two likely reasons for this are (1) the blanket freight rate for shipments to the west, and (2) the Duluth elevators were near full-storage with government grain. Estimating a price impact using this methodology is impossible because of the differing results from the two terminal markets. The market indicating a statistically significant price impact was a market receiving declining North Dakota barley shipments, and in fact, may have been at storage capacity and unable to purchase much grain during the period of analysis.

TABLE 7. COMPARISON OF DULUTH AND PACIFIC NORTHWEST TERMINAL MARKET-LOCAL MARKET BARLEY PRICE SPREADS BEFORE AND AFTER OPENING OF DAWN ENTERPRISES ETHANOL PLANT, JANUARY 1985 TO MAY 1986

	Duluth-Local Spread		Pacific Northwest-Local Spread	
	Pre-Dawn Mean	Post-Dawn Mean	Pre-Dawn Mean	Post-Dawn Mean
	dollars		dollars	
All towns	.42*	.12*	.74	.74
Crystal	.40*	.11*	.72	.72
Devils Lake	a	a	a	a
Ellendale	a	a	a	a
Forest River	.46*	.15*	.78	.77
Gwinner	a	a	a	a
Harvey	.46*	.10*	.78	.71
Hunter	.36*	.11*	.68	.72
Jamestown	.43*	.04*	.75*	.66*
Langdon	.46*	.12*	.78	.74
Larimore	.42*	.12*	.74	.73
McVille	.44*	.15*	.76	.76
Rugby	a	a	a	a
Thompson	.37*	.16*	.69*	.77*
Valley City	.40*	.13*	.72	.74
West Fargo	.38*	.12*	.70	.74
Hallock,Mn	.46*	.23*	.78	.84

*Denotes significance at the 10 percent level.
[a]Unable to calculate due to missing observations.

TABLE 8. BARLEY MOVEMENTS FROM NORTH DAKOTA TO MAJOR MARKETS, MARKETING YEARS 1984-85 AND 1985-86

Year	Duluth Superior	Minneapolis St. Paul	Other MN and Wisc.	Midland & Southwest	Pacific Northwest	N.D.	Other	Total
	percent							
1984-85	25	21	18	6	9	15	6	100
1985-86	8	19	19	22	9	16	7	100

SOURCE: Zink and Ogg 1985; Zink and Ogg 1986.

Local Market Price Comparisons

Local market prices are determined by subtracting freight and margins from the destination market price. For barley, two terminal markets were considered, the Pacific Northwest and the Duluth markets; the Minneapolis market was used for corn. Subtracting freight and margin from the terminal market provides an estimate of the local elevator board price available to farmers. This relationship is represented as follows:

$$P_{LT} = P_T - F_T - M_L$$

where

P_{LT} = price at local market L based on terminal market T price
P_T = price at terminal market T
F_T = freight to terminal market T
M_L = margin for local elevator L

Prices at local elevators also were determined based on contract prices paid for barley and corn by the Walhalla ethanol plant. Local elevator prices would be the Walhalla ethanol contract price less freight to Walhalla and the local elevators' margin. This relationship can be shown as follows:

$$P_{LD} = P_D - F_D - M_L$$

where

P_{LD} = price at local elevator L based on Dawn Enterprises' price
P_D = price paid by Dawn Enterprises
F_D = freight to Walhalla ethanol plant (assumed to be truck rates because of distance to local elevators)
M_L = margin for local elevator L

The price impact of the ethanol plant would be the difference between the local elevator price using Dawn Enterprises' prices and the local elevator

price with respect to the terminal markets. This relationship would be represented as follows:

$$I_P = P_{LD} - P_{LT}$$

where

I_P = impact on price as a result of the Walhalla ethanol plant
P_{LD} = price at local elevator L based on Dawn Enterprises' prices
P_{LT} = price at local market L based on terminal market T price

Local elevator prices published by Agweek were not used to determine the price impact of the Walhalla ethanol plant but were used as a benchmark to validate the local market price based on the Dawn Enterprise price and the terminal market price. Theoretically, the price impact (I_P) of the Walhalla plant would be greater near the plant and decrease as distance to the local elevator increases. Such results would reflect transportation costs and the ability to acquire adequate feedstocks within a reasonable proximity.

Results from this methodology were inconclusive with respect to determining the impact that the Walhalla ethanol plant purchases had on barley and corn prices. No price impact or pattern emerged when comparing the local price from the three sources (i.e., based on published prices, based on Dawn Enterprises prices, and based on terminal market prices). What became apparent when evaluating the results was that determining prices using this methodology was a much too crude an approach to estimate pricing impacts with any degree of reliability. Several factors contributed to the problems encountered and included: (1) tariff rates differed considerably from contract rail rates; (2) local elevator margins obtained from secondary data sources (Cobia et al. 1986) may represent the industry, but local elevator margins can differ significantly; (3) the margin Cargill charged Dawn Enterprises[1] to serve as their licensed and bonded grain buyer made it virtually impossible to estimate margins on grain sold to the Walhalla ethanol plant; (4) much of the grain delivered to Dawn Enterprises was never physically handled or title taken by the local elevators; (5) transportation costs were borne by farmers who delivered their grain to the ethanol plant; and (6) published elevator prices may or may not reflect local elevators that were actively marketing grain to the Walhalla ethanol plant. Reviewing the numerous price determination problems encountered with this methodology and the range of variability in pricing that could result from each makes it easy to understand that the results were inconclusive and virtually meaningless. Because the results obtained from this methodology were inconclusive, they will not be presented in this report. Although the results are not presented, it is important that the methodology be presented and the problems encountered be identified so they could possibly be addressed by future research efforts.

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[1]In order to purchase grain, Dawn Enterprises needed to be licensed and bonded. From the time of their initial grain purchases through June, 1986, Cargill Inc. of Riverside was contracted to provide this marketing service. Cargill received a 5 cent per bushel margin, although they never physically handled or took title to the grain, while this agreement was in effect (Thornberg 1986).

Much of the data needed to complete the analysis with this research technique are proprietary, and in all likelihood could not be obtained.

Statistical Comparisons

Price impacts of the Walhalla ethanol plant also were estimated using statistical techniques. Regression analysis was employed to determine if price impacts resulted with the opening of the ethanol plant and the magnitude of the impact. For this analysis, freight and margins were not a part of the solutions, and thus the two variables most difficult to quantify and having the largest variability were eliminated. Data required for this analysis included the prices paid for barley at the Walhalla ethanol plant (Dawn Enterprises 1986a), Duluth #2 feed barley prices (Agweek 1985-1986), and PNW #2 feed barley prices (Agricultural Marketing Service 1985-1986); prices paid for corn at the ethanol plant (Dawn Enterprises 1986b) and at Minneapolis (Agweek 1985-1986) were used to analyze the price impact on corn.

Contract price data for Dawn Enterprises were available only on a monthly basis (i.e., contracts were written for delivery in a given month). As a result of this, all price data were aggregated to a monthly basis and the analysis performed on monthly price data. All price data were aggregated using simple averaging techniques. Data were collected for the terminal markets (Duluth, PNW, and Minneapolis) for the period January 1985 to May 1986.[2] Dawn Enterprises contract purchases for barley began in July 1985, and the first corn contracts were in December 1985. This provided six months of price data before Dawn Enterprises started purchasing barley and 11 months of data while the ethanol plant was in operation. Corn prices were for 11 months prior to Dawn Enterprises purchases and for six months during their operation.

Monthly average board prices at local elevators are presented for barley and corn in Tables 9 and 10, respectively. Terminal market prices for barley (Duluth and PNW) and corn (Minneapolis) are given in Table 11. Monthly barley and corn contract purchases by Dawn Enterprises and the monthly weighted average prices are presented in Table 12.

Statistical models were developed to analyze the data as two different cases, one for the absolute price levels and another for monthly price changes. Models were set up for each of the 16 towns and for all towns aggregated for barley and corn. The models developed will be presented mathematically and discussed in the sections that follow.

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[2]Dawn Enterprises' price data were not readily available after May 1986 because of a change-over in their computerized accounting system. The data were available but only on assembly sheets and would have required someone to copy the numbers off each assembly sheet (i.e., each truckload record). Dawn Enterprises personnel were willing to provide the data when they were computerized, but time constraints of the study precluded use of the data.

TABLE 9. MONTHLY AVERAGE BOARD PRICE FOR FEED BARLEY AT SIXTEEN SELECTED TOWNS IN NORTH DAKOTA AND MINNESOTA, JANUARY 1985 TO MAY 1986

Town	1985												1986				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	dollars																
Crystal	1.77	1.79	1.82	1.83	1.77	1.63	1.54	1.46	1.37	1.44	1.60	1.69	1.60	1.47	1.54	1.52	1.36
Devils Lake	--	--	--	--	--	--	--	1.36	1.33	1.41	1.54	1.67	1.65	1.51	1.54	1.53	1.32
Ellendale	--	--	--	--	--	--	--	--	--	1.39	1.47	1.61	1.62	1.50	1.59	1.59	1.36
Forest River	1.71	1.73	1.76	1.77	1.71	1.60	1.53	1.28	1.26	1.35	1.48	1.62	1.61	1.51	1.55	1.56	1.33
Gwinner	--	--	--	--	--	--	--	--	1.34	1.39	1.40	1.62	1.65	1.60	1.62	1.64	1.52
Harvey	1.80	1.77	1.75	1.77	1.64	1.52	1.45	1.44	1.35	1.41	1.61	1.68	1.65	1.62	1.60	1.54	1.32
Hunter	1.74	1.84	1.85	1.88	1.84	1.71	1.52	1.38	1.40	1.40	1.46	1.53	1.62	1.49	1.68	1.70	1.38
Jamestown	1.77	1.76	1.74	1.81	1.73	1.63	1.52	1.51	1.50	1.53	1.63	1.75	1.69	1.55	1.62	1.59	1.39
Langdon	1.75	1.78	1.74	1.74	1.70	1.56	1.47	1.47	1.35	1.42	1.56	1.66	1.61	1.50	1.51	1.53	1.35
Larimore	1.75	1.77	--	1.82	1.76	1.64	1.50	1.36	1.32	1.44	1.59	1.69	1.64	1.50	1.54	1.54	1.36
McVille	1.75	1.74	1.77	1.82	1.73	1.61	1.45	1.36	1.31	1.39	1.50	1.65	1.63	1.49	1.52	1.55	1.33
Rugby	--	--	--	--	--	--	--	1.40	1.41	1.44	1.50	1.69	1.69	1.57	1.60	1.55	1.36
Thompson	1.76	1.77	1.83	1.86	1.83	1.75	1.52	1.34	1.33	1.36	1.52	1.65	1.60	1.47	1.50	1.48	1.26
Valley City	1.79	1.80	1.81	1.83	1.75	1.63	1.43	1.44	1.45	1.41	1.55	1.68	1.64	1.46	1.50	1.49	1.31
West Fargo	1.78	1.79	1.82	1.85	1.82	1.71	1.53	1.42	1.45	--	1.59	1.62	1.57	1.51	1.50	1.48	1.27
Hallock, MN	1.70	1.72	1.72	1.81	1.74	1.60	1.45	1.33	1.23	1.19	1.30	1.45	1.53	1.49	1.48	1.49	1.31

TABLE 10. MONTHLY AVERAGE BOARD PRICE FOR CORN AT SIXTEEN SELECTED TOWNS IN NORTH DAKOTA AND MINNESOTA, JANUARY 1985 TO MAY 1986

Town	1985												1986				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	dollars																
Crystal	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Devils Lake	--	--	--	--	--	--	--	2.20	2.10	2.10	2.04	2.00	2.00	2.00	1.95	1.90	1.89
Ellendale	--	--	--	--	--	--	--	--	--	2.12	2.17	2.27	2.30	2.24	2.19	2.15	2.22
Forest River	2.33	2.42	--	--	--	--	--	--	--	--	2.19	2.30	--	--	--	--	--
Gwinner	--	--	--	--	--	--	--	--	2.42	2.22	2.18	2.23	2.24	2.23	2.24	2.21	2.26
Harvey	2.45	2.49	2.44	2.49	2.48	2.60	2.55	2.07	2.00	2.02	2.08	2.00	2.05	2.10	2.10	2.10	2.10
Hunter	2.43	2.47	2.53	2.59	2.55	2.55	2.48	2.23	2.27	2.18	2.20	2.23	2.20	2.21	2.18	2.17	2.17
Jamestown	2.37	2.40	2.39	2.47	2.52	2.49	2.45	2.31	2.22	2.03	2.05	2.12	2.15	2.15	2.14	2.18	2.16
Langdon	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Larimore	2.44	2.42	--	2.57	2.47	2.35	2.20	2.22	2.21	2.11	2.14	--	--	--	--	--	--
McVille	2.40	2.43	2.45	2.45	2.45	2.45	2.44	2.17	2.12	1.97	2.00	2.00	2.00	2.00	1.99	2.00	2.00
Rugby	--	--	--	--	--	--	--	--	--	--	--	2.40	--	--	--	--	--
Thompson	2.38	2.46	2.47	2.50	2.50	2.50	2.44	2.12	2.35	2.10	2.14	2.19	2.17	2.17	2.15	2.15	2.11
Valley City	2.39	2.38	2.33	2.32	2.33	2.40	2.17	2.13	2.19	2.23	2.19	2.18	2.14	2.07	2.02	2.03	2.10
West Fargo	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hallock, MN	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 11. MONTHLY AVERAGE TERMINAL MARKET PRICES FOR DULUTH AND PACIFIC NORTHWEST #2 FEED BARLEY AND MINNEAPOLIS CASH CORN, JANUARY 1985 TO MAY 1986

Month	#2 Feed Barley		Minneapolis Cash Corn
	Duluth	PNW	
	dollars		
1985			
Jan	2.18	2.54	2.58
Feb	2.13	2.54	2.62
Mar	2.19	2.52	2.75
Apr	2.25	2.50	2.79
May	2.23	2.48	2.74
Jun	2.05	2.37	2.70
Jul	1.81	2.26	2.60
Aug	1.66	2.14	2.44
Sep	1.63	2.06	2.38
Oct	1.63	2.20	2.21
Nov	1.71	2.34	2.32
Dec	1.80	2.48	2.34
1986			
Jan	1.72	2.36	2.28
Feb	1.50	2.16	2.25
Mar	1.35	2.16	2.30
Apr	1.46	2.21	2.32
May	1.50	2.16	2.47

TABLE 12. BARLEY AND CORN CONTRACT PURCHASES BY DAWN ENTERPRISES, AND WEIGHTED AVERAGE PRICE, BY MONTH, JULY 1985 TO MAY 1986

Month	Barley		Corn	
	Purchases	Weighted Price	Purchases	Weighted Price
	--- bu ---	---- $/bu ----	--- bu ---	---- $/bu ----
1985				
Jul	60,009	1.65	--	--
Aug	267,277	1.54	--	--
Sep	42,509	1.45	--	--
Oct	251,209	1.59	--	--
Nov	362,138	1.72	--	--
Dec	227,762	1.80	47,732	2.15
1986				
Jan	145,352	1.78	204,509	2.28
Feb[a]	--	--	241,266	2.42
Mar	12,721	1.70	164,326	2.50
Apr	227,984	1.73	113,325	2.43
May	286,957	1.65	84,138	2.14

[a]No barley was contracted for delivery in February 1986.

Statistical Model

Prices paid by local elevators typically are related to the price at the terminal market. This relationship can be represented mathematically as follows:

$$P_L = \gamma_0 + \gamma_1 P_T$$

where

P_L = price at local elevator
γ_0 = intercept
$\gamma_1 P_T$ = slope coefficient times price at terminal market T

This relationship is presented graphically in Figure 3. The intercept (γ_0) represents the implied margins and transportation costs which were discussed in detail in the local market price comparisons earlier in this report. The extent to which the terminal and local market are related is measured by the γ_1 term. If the markets are highly related, the γ_1 term would be near or equal to 1.0. Regression analysis can determine the coefficients for the above equation and their significance. In order to determine whether entry of Dawn Enterprises into the local barley and corn markets resulted in price impacts, a pre- and post-Dawn situation must be incorporated into the equation.

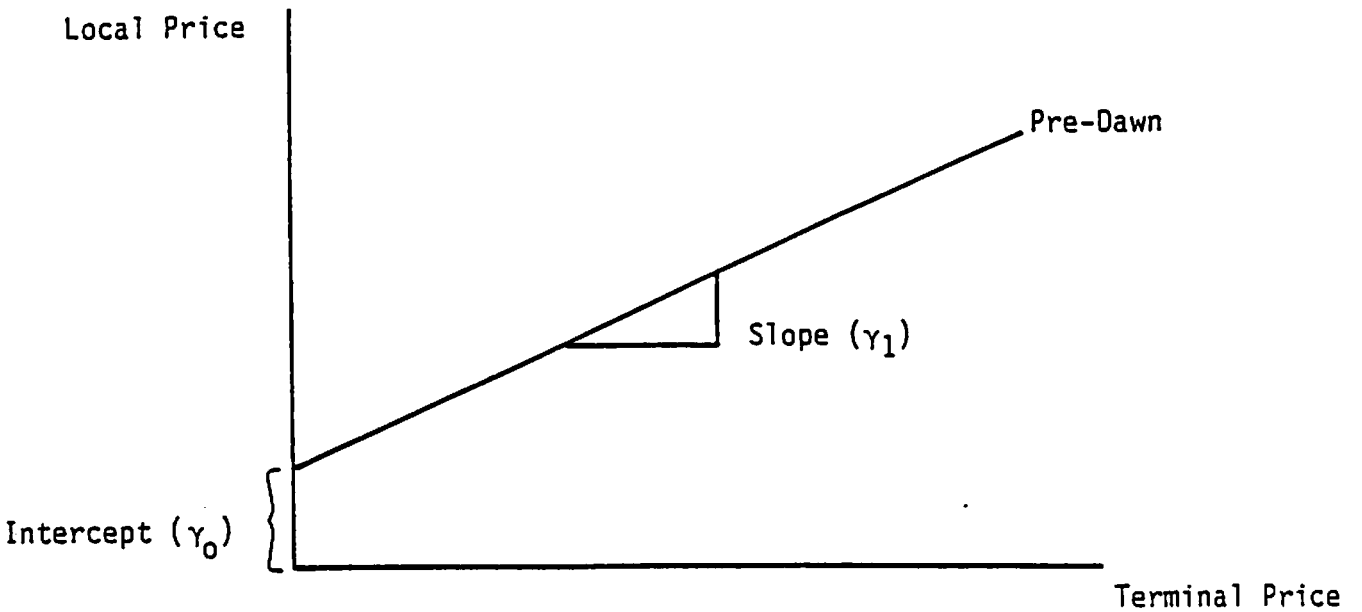

Figure 3. Graphic Representation of Local Market and Terminal Market Price Relationship

Addition of a dummy variable into the equation to represent Dawn Enterprises' entry into the market provides an indicator of a price impact (i.e., a 0 or 1 variable was added to the data set with the 0 indicating nonoperation of the plant and 1 indicating plant operation). An intercept dummy variable alters the basic relationship as follows:

$$P_L = \gamma_o + \gamma_1 P_T + \beta_o W$$

where

P_L = price at local elevator
γo = original intercept
$\gamma_1 P_T$ = slope coefficient times price at terminal market T
$\beta_o W$ = intercept change resulting from entry of the Walhalla ethanol plant into the market

This equation is presented graphically in Figure 4. The equation can be further expanded to include a dummy slope term:

$$P_L = \gamma_0 + \gamma_1 P_T + \beta_0 W + \beta_1 W P_T$$

where

P_L = price at local elevator
γ_0 = original intercept
$\gamma_1 P_T$ = original slope coefficient times price at terminal market T
$\beta_0 W$ = intercept change resulting from entry of the Walhalla ethanol plant into the market
$\beta_1 W P_T$ = new slope coefficient times the Walhalla dummy variable times price at terminal market T

This equation captures not only a shift in the intercept of the mathematical relationship between the local and terminal market prices but also a change in the slope relationship (Figure 5).

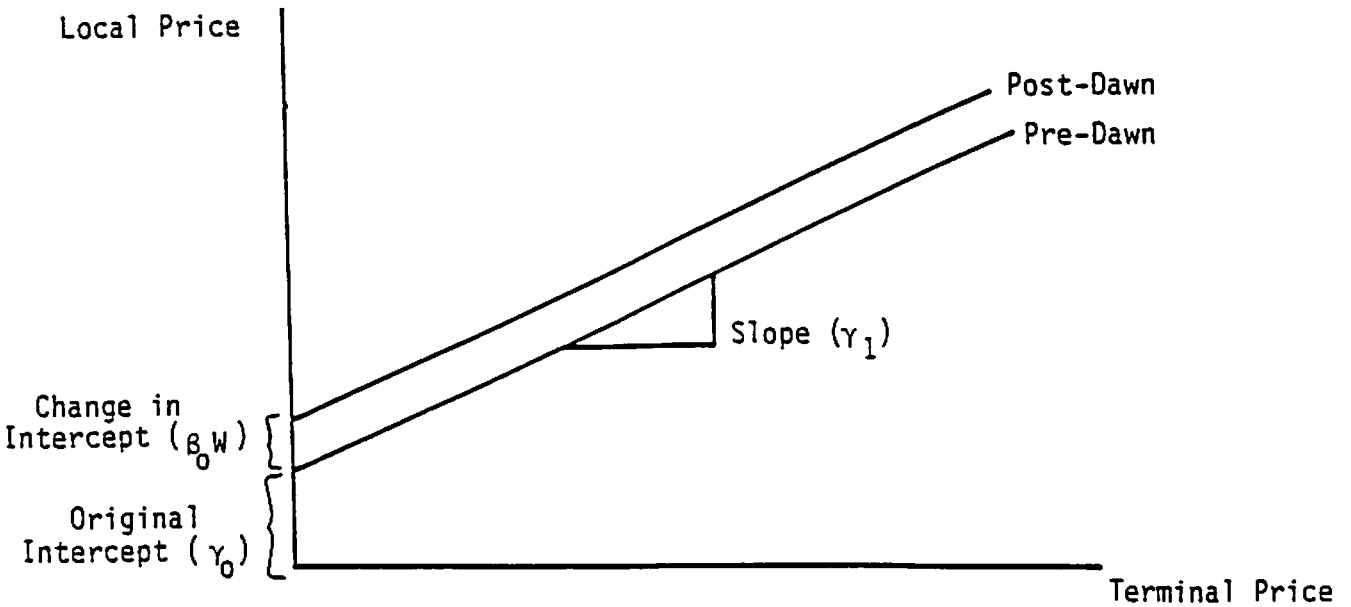

Figure 4. Graphic Representation of Local Market and Terminal Market Price Relationship After Introduction of a Dawn Enterprise Dummy Intercept Variable

Equations containing the intercept dummy variable ($\beta_0 W$) and the intercept and slope dummy variables ($\beta_0 W + \beta_1 WP_T$) were used for this analysis. Both sets of equations were used for barley and corn for the appropriate terminal markets. The analysis was performed for each town and for aggregated data for the 16 towns. Because of the short time period that data were

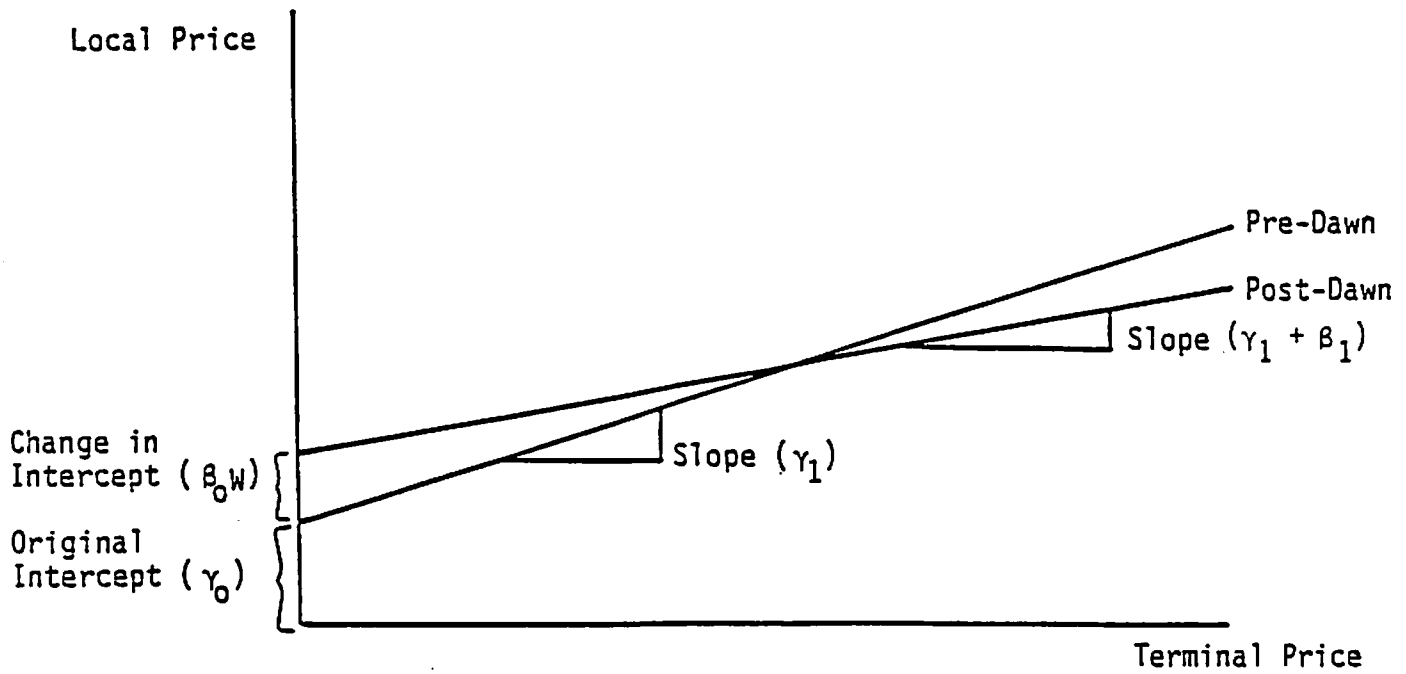

Figure 5. Graphic Representation of Local Market and Terminal Market Relationship After Introduction of a Dawn Enterprise Dummy Intercept and Slope Variable

available after Dawn Enterprises began operations, statistical significance and inability to determine full rank solutions were problems encountered.[3]

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[3]A second statistical approach to determining a price impact involving price changes at the local and terminal markets also encountered data problems. The price change was determined from month to month and similar regression analysis was performed. These relationships are represented mathematically as follows:

$$\Delta P_L = \gamma_0 + \gamma_1 \Delta P_T$$

where

ΔP_L = change in price at the local elevator
γ_0 = intercept
$\gamma_1 \Delta P_T$ = slope coefficient times the change in price at terminal elevator T

$$\Delta P_L = \gamma_0 + \gamma_1 \Delta P_T + \beta_0 W$$

where

ΔP_L = change in price at the local elevator
γ_0 = original intercept
$\gamma_1 \Delta P_T$ = slope coefficient times the change in price at terminal market T
$\beta_0 W$ = intercept change resulting from Dawn Enterprises entry into the market

$$\Delta P_L = \gamma_0 + \gamma_1 \Delta P_T + \beta_0 W + \beta_1 W \Delta P_T$$

where

γ_0 = original intercept
$\gamma_1 \Delta P_T$ = slope coefficient times the change in price at terminal market T
$\beta_0 W$ = intercept change resulting from the entry of the Walhalla ethanol plant into the market
$\beta_1 W \Delta P_T$ = new slope coefficient times the Walhalla dummy variable times change in price at terminal market T

Data shortage problems were compounded with this model because the monthly change calculations consumed an additional degree of freedom from each data set. As a result, most equations were not full rank solutions, and no coefficients were significant at the 10 percent level. A discussion of this methodology was presented because it does have merit and, if more data were available, the results from this statistical model could be very beneficial in determining the price impact purchases by the Walhalla ethanol plant had on local markets.

The statistical models for corn contained only six observations for the Dawn Enterprises' corn prices (and the dummy intercept and slope variables) which resulted in full rank error results for all solutions. Therefore, the corn models were inconclusive and are not presented in this report. Results from the barley models were more satisfactory and are presented in the section that follows.

Statistical Model Results

Statistical models were developed to estimate the relationship between barley prices at local elevators to the price at terminal markets for 16 towns and for all of those towns combined. The relationship of local barley prices to the Duluth market was best explained by the equation using the intercept, slope, dummy slope, and dummy intercept coefficients. Results of this model are presented in Table 13. The coefficients for the equation for all towns combined indicates the slope (γ_1), the dummy intercept (β_0) and the dummy slope (β_1) are significant at the 10 percent level. A β_0 value of 1.12 would indicate the presence of a price impact; however, the negative slope (-.60) of the dummy slope coefficient (β_1) tends to override the β_0 price

TABLE 13. COEFFICIENTS DETERMINED FOR STATISTICAL MODEL USING LOCAL BARLEY PRICES AS A FUNCTION OF THE DULUTH MARKET

Town	γ_0	γ_1	β_0	β_1	R^2
All towns combined	.17	.73*	1.12*	-.60*	.60
Crystal	-.02	.82	1.05	-.53	.77
Devils Lake	a	a	a	a	a
Ellendale	a	a	a	a	a
Forest River	.22	.69	1.10	-.60	.59
Gwinner	a	a	a	a	a
Harvey	-.15	.86	1.54	-.78	.46
Hunter	.31	.69	1.60	-.94	.74
Jamestown	.29	.67	.95	-.46	.58
Langdon	.24	.68	.91	-.46	.67
Larimore	.20	.71	.94	-.49	.64
McVille	-.08	.84	1.33	-.70	.69
Rugby	a	a	a	a	a
Thompson	.65	.53	.31	-.22	.79
Valley City	.11	.76	.91	-.47	.77
West Fargo	.43	.63	.55	-.31	.84
Hallock, MN	-.14	.86	1.68	-.95	.76

*Denotes significance at the 10 percent level
[a]Indicates not full rank solution

impact. This equation is similar to the graph presented in Figure 5. The statistical model for the Duluth market is as follows:

$$P_L = .17 + .73(P_T) + 1.12(W) - .60(W)\ (P_T)$$

where

P_L = price at local elevator
P_T = price at terminal market (Duluth)
W = dummy variable indicating operation of the Walhalla ethanol plant

These results indicate that in the post-Dawn period (i.e., W = 1.0) the local barley prices became increasingly divorced from, or less influenced by the Duluth feed barley market. Similar results can be observed in Table 5.

A price impact can be analyzed using this equation by calculating the partial derivative of P_L with respect to W, which mathematically is

$$\frac{\partial P_L}{\partial W} = 1.12 - .60(P_T)$$

Using actual values for P_T helps to illustrate the difficulties with using this model. Prices during the period of the analysis ranged from $2.25 to $1.35 at the Duluth market. With barley prices at $2.25 per bushel the price impact is -$.23 per bushel, whereas at a lower price, such as $1.35 per bushel, the price impact is $.31 per bushel. Thus, at lower prices, this relationship indicates a positive price impact, but at higher prices it appears to be a negative impact. No price impact (either positive or negative) was realized at a price of $1.87.

None of the coefficients for the individual towns were significant, and therefore drawing conclusions for that level would be statistically unreliable. The coefficients indicate that there is a change in the relationship between the local and Duluth market prices when the dummy variable is included; however, they do not conclusively show a price impact and the magnitude of that impact. Several factors are involved in the inability to draw solid conclusions: (1) the short time period for which data were available, (2) the smoothing effect of using monthly data (i.e., weekly data were simple averages of daily data and monthly data were the simple averages of weekly data), (3) the sharp and steady decline in barley prices during the analysis period, (4), the initiation of a new federal farm program with a change in basic philosophy, (5) the large surpluses of feed grains that existed during this period, (6) the dynamic market conditions existing at this time, and (7) the rather small share of total barley stocks purchased by the ethanol plant and the close proximity of adequate supplies to operate the plant.

Local barley prices also were tested for their relationship to the Pacific Northwest market. The coefficients showed that only the slope (γ_1) was significant for all towns combined (Table 14). Lack of significance for the ethanol plant dummy intercept (β_0) and slope (β_1) indicates the Walhalla ethanol plant did not affect the relationship between the local market and Pacific Northwest price, and thus this equation could not estimate a price

TABLE 14. COEFFICIENTS DETERMINED FOR STATISTICAL MODEL USING LOCAL BARLEY PRICES AS A FUNCTION OF THE PACIFIC NORTHWEST MARKET

Town	γ_0	γ_1	β_0	β_1	R^2
All towns combined	-.32	.83*	.38	-.19	.75
Crystal	-.65	.97*	.49	-.22	.93
Devils Lake	a	a	a	a	a
Ellendale	a	a	a	a	a
Forest River	-.27	.79	-.03	-.01	.79
Gwinner	a	a	a	a	a
Harvey	-2.28	1.60*	2.19	-.88	.75
Hunter	.40	.57	.45	-.27	.73
Jamestown	-.26	.81*	.39	-.16	.81
Langdon	-1.30*	1.21*	1.27*	-.52*	.91
Larimore	-.13	.76*	-.31	.12	.90
McVille	-.44	.88*	.21	-.11	.87
Rugby	a	a	a	a	a
Thompson	1.35	.18	-1.73	.65	.91
Valley City	-.82	1.04*	.79	-.36	.90
West Fargo	.35	.50	-.32	.06	.89
Hallock, MN	-.01	.69	.56	-.32	.77

*Denotes significance at the 10 percent level
[a]Indicates not full rank solution

impact. Several individual towns had significant values for the slope (γ_1) and Langdon had all values significant. However, the β_0 term (1.27) again is offset by the negative nature of the dummy slope (β_1 = -.52), very similar to the Duluth-all towns combined equation previously discussed. The relationship of local prices to those of Dawn Enterprises was determined and is presented in Table 15. This equation best reflected the local price as being a function of the Walhalla ethanol plant barley price (slope and intercept) with only a dummy intercept term. Results indicate that the dummy variable (β_0) was not statistically significant. Many individual towns had a statistically significant slope coefficient (γ_1), but none of the dummy coefficients (β_0) were significant. Statistical models indicate that there is no price impact based on the Pacific Northwest or the Walhalla ethanol market prices.

Towns included in analysis up to a 50-mile radius of the ethanol plant were aggregated and models were developed to determine their relationship to the market at Duluth, the Pacific Northwest, and the Walhalla ethanol plant. The equation included both intercept and slope dummy terms. Results from these models were consistent with those previously developed and are presented in Table 16. Both the Duluth and Pacific Northwest models had β_0 and β_1 terms that were not statistically significant, and the ethanol plant market did not have sufficient data to give a full rank solution. Overall, the results of the statistical models could not conclusively indicate a price impact or the amount of the impact based on available data, although the Duluth model did

TABLE 15. COEFFICIENTS DETERMINED FOR STATISTICAL MODEL USING LOCAL BARLEY PRICES AS A FUNCTION OF DAWN ENTERPRISES PRICES

Town	γ_0	γ_1	β_0	R^2
All towns combined	-.13	.86*	.18	.56
Crystal	-.15	.79*	.35	.67
Devils Lake	2.18	1.01*	1.98	.78
Ellendale	-2.25	1.28*	1.58	.71
Forest River	1.65	1.15*	-2.11	.83
Gwinner	a	a	a	a
Harvey	1.26	.96*	-1.36	.70
Hunter	.76	.75*	-.50	.44
Jamestown	1.42	.68*	-.98	.51
Langdon	.82	.78*	-.63	.69
Larimore	.21	1.05*	-.46	.84
McVille	1.06	1.00*	-1.25	.82
Rugby	-.77	.87*	.85	.65
Thompson	2.13	.93*	-2.22	.64
Valley City	1.28	.66*	-.89	.43
West Fargo	-1.68	.51	2.32	.29
Hallock, MN	.48	.79*	-.43	.54

*Denotes significance at the 10 percent level
[a]Indicates not full rank solution

indicate a shift in the relationship. Problems encountered, as previously discussed, provide the explanation for the inability to draw definite conclusions.

TABLE 16. COEFFICIENTS DETERMINED FOR STATISTICAL MODEL USING LOCAL BARLEY PRICES AS A FUNCTION OF A SELECTED MARKET FOR TOWNS UP TO A 50-MILE DISTANCE FROM THE WALHALLA ETHANOL PLANT

Market	γ_0	γ_1	β_0	β_1	R^2
Duluth	.02	.78*	1.21	-.65	.66
Pacific Northwest	-.65	.96*	.77	-.36	.77
Walhalla Ethanol Plant	a	a	a	a	a

*Denotes significance at the 10 percent level
[a]Indicates not full rank solution

Elasticity Model

Price impacts can also be determined if required economic measures are known. An equation can be derived to show the price change if the original price and demand, the change in demand, and the elasticities of supply and demand are known. An understanding of the elasticities of supply and demand are a central feature to this type of approach. Studies have estimated elasticities for grains and these findings have been applied to a change in demand for corn to estimate the price impact. Umbeck (1985) estimated the price impact of a change in demand for corn using a price elasticity of supply of .4 and the demand elasticity of .2. These elasticities were national values and were not believed to be applicable to the North Dakota barley (feed grain) situation. Elasticity of demand studies were reviewed by Gardiner (1986) and showed a wide range of values. The elasticity of demand for corn ranged from .26 to 3.7; elasticities of supply were not estimated in these studies. Studies showing the elasticities of supply and demand for barley were not available, and specifically no estimates of North Dakota local elasticities of barley were found.

The law of demand indicates that consumers will respond to a price decline by buying more of a product. Consumer responsiveness to price changes may vary considerably from product to product. Economists measure the degree to which consumers respond to a change in the price of a product by the concept of elasticity. Demand for some products is such that consumers are relatively responsive to price changes (i.e., small price changes result in large changes in the quantity purchased, and demand is thus termed elastic). Demand is inelastic for products for which consumers are relatively unresponsive to price changes; that is, large price changes result in only small changes in quantity demanded. Elasticity of demand is defined as:

$$E_d = \frac{\% \Delta Q_d}{\% \Delta P}$$

where

E_d = elasticity of demand
$\%\Delta Q_d$ = percentage change in quantity demanded
$\%\Delta P$ = percentage change in price

Demand is elastic if $|E_d| > 1$ and inelastic if $|E_d| < 1$. For example, if the price of barley increased by 2 percent and as a result the barley buyers reduced their purchases by 3 percent, the E_d would be -1.5 and the demand

$$E_d = \frac{\%\Delta Q_d}{\% \Delta P} = \frac{-3.0}{2.0} = -1.5$$

would be relatively elastic. However, if the 2 percent price increase had resulted in buyers reducing their purchases by 1 percent, the E_d would be .5

$$E_d = \frac{\%\Delta\ Q_d}{\%\ \Delta\ P} = \frac{-1.0}{2.0} = -.5$$

and therefore relatively inelastic. Figure 6 presents two demand curves--D_1 and D_2. For any price, D_1 is relatively more elastic than D_2 (or D_2 is relatively more inelastic than D_1).

The concept of elasticity can also be applied to supply. If producers are responsive to price changes, the supply is elastic; if they are relatively insensitive to price change, the supply is inelastic. Elasticity of supply can be expressed as follows:

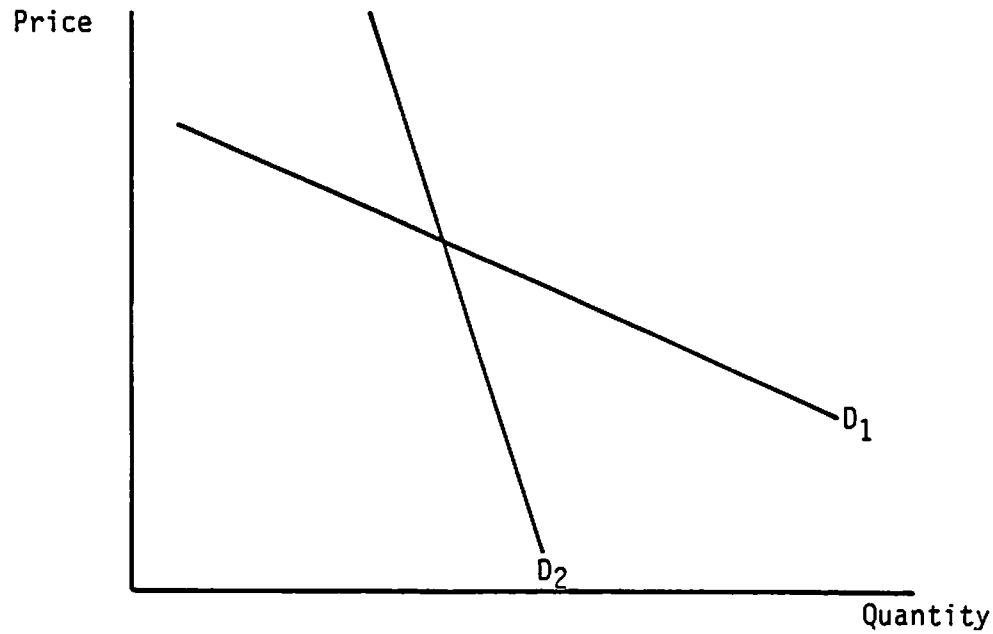

Figure 6. Graphic Representation of an Elastic and an Inelastic Demand Curve

$$E_S = \frac{\% \Delta Q_S}{\% \Delta P}$$

where

E_S = elasticity of supply
$\%\Delta Q_S$ = percentage change in quantity supplied
$\%\Delta P$ = percentage change in price

Two supply curves, S_1 and S_2, are presented in Figure 7. For any given price, S_1 is relatively more elastic than S_2 (or S_2 is relatively more inelastic than S_1). For instance, if a 1 percent increase in the price of barley resulted in farmers increasing their production by 3 percent, E_S would equal 3.0

$$E_S = \frac{\% \Delta Q_S}{\% \Delta P} = \frac{3.0}{1.0} = 3.0$$

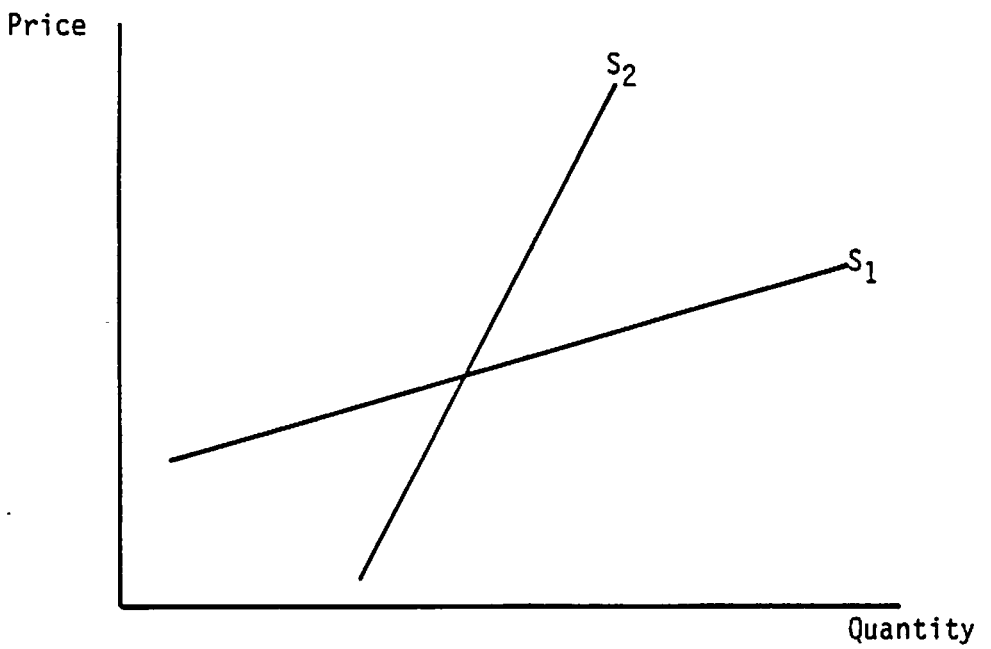

Figure 7. Graphic Representation of an Elastic and an Inelastic Supply Curve

and the elasticity of supply would be relatively elastic (greater than 1). However, if the 1 percent price increase caused farmers to increase their production by only .5 percent, the elasticity of supply would be relatively inelastic, or less than 1.0

$$E_s = \frac{\% \Delta Q_s}{\% \Delta P} = \frac{.5}{1.0} = .5$$

Price changes attributed to a given change in demand can be calculated if the regional price and quantity are known, as well as the elasticity of demand and supply. This equation can be derived from the equilibrium quantity demanded and supplied.
The derivation is as follows:

$$Q_d = a + bP$$

where

Q_d = quantity demanded
a = intercept
b = slope coefficient
P = price

$$Q_s = c + dP$$

where

Q_s = quantity supplied
c = intercept
d = slope coefficient
P = price

The elasticities of supply and demand can be determined by using partial derivitive of quantity with respect to price. Derivation is as follows:

$$E_d = \frac{\partial Q}{\partial P} \cdot \frac{P}{Q}$$

$$\frac{\partial Q}{\partial P} = b$$

$$E_d = b \cdot \frac{P}{Q}$$

$$b = E_d \cdot \frac{Q}{P}$$

where

E_d = elasticity of demand

$\frac{\partial Q}{\partial P}$ = partial derivative of Q with respect to P

P = price

Q = quantity

$$E_s = \frac{\partial Q}{\partial P} \cdot \frac{P}{Q}$$

$$\frac{\partial Q}{\partial P} = d$$

$$E_s = d \cdot \frac{P}{Q}$$

$$d = E_s \cdot \frac{Q}{P}$$

where

E_s = elasticity of supply

$\frac{\partial Q}{\partial P}$ = partial derivative of Q with respect to P

P = price

Q = quantity

A shift in parameters can be incorporated into the relationship, and at equilibrium (where the quantity demanded equals the quantity supplied) the equation can be solved for P.

$$P_o = \frac{a - c}{d - b}$$

A change in price (to P_1) can be calculated as follows:

$$P_1 = P_o + \frac{\Delta a}{d - b} - \frac{\Delta c}{d - b}$$

where

P_1 = new price
P_o = original price
Δa = shift in the demand intercept
Δc = shift in the supply intercept
d = demand slope coefficient
b = supply slope coefficient

For the purposes of analyzing the price impact of purchasing barley or corn for the ethanol plant, the term for a change in supply can be eliminated (i.e., the Δc term equals 0) because the presumed price impact is caused by a shift (change) in demand. Elasticities previously calculated can be substituted into the equation for the slope coefficients to form the elasticity model as follows:

$$P_1 = P_0 + \frac{\Delta a}{d - b}$$

$$P_1 = P_0 + \frac{\Delta a}{(E_s - E_d)\frac{Q}{P_0}}$$

For a complete discussion and derivation of the equation to calculate price impacts using elasticities of supply and demand, see Appendix B and Archibald and Lipsey (1973).

The difficulty with using the elasticity approach to determine price impact is the widespread difference of opinion as to what the elasticities of demand and supply really are and the shape of the supply curve itself. The current supply curve for barley does not necessarily resemble the classic curve sloping upward to the right. Federal farm programs have altered the shape of the curve in effect by creating a price floor at the loan rate. Participation in the barley program in 1985 and 1986 was extremely high (74 and 83 percent, respectively) and brought almost all bushels produced under the price protection of the loan rate (Table 17). High participation in

TABLE 17. NORTH DAKOTA BARLEY BASE, ACREAGE ENROLLED, AND PERCENT OF BASE ACREAGE ENROLLED IN THE FEDERAL GOVERNMENT FARM BARLEY PROGRAM, 1985 TO 1986

Year	Barley Base	Enrolled in Program	Portion Enrolled
	acres		percent
1985	3,229,700	2,395,800	74
1986	3,010,543	2,497,906	83

the barley farm program would cause the supply curve to be virtually flat (perfectly elastic) up to some point (Figure 8). In effect, this supply curve is one in which producers supply little or no barley at prices below the loan rate. Nonprogram barley or barley of insufficient quality for loans under the farm program would be the only grain available when price was below the loan rate.

When using the elasticity approach to estimate price impacts it is critical to know location of the original demand curve relative to the supply curve. For example, in Figure 9 if the original demand curve D_1 shifts to D_2 on the horizontal portion of supply curve S_1, there would be no price impact. Along the horizontal section of S_1, shifts in demand (either an increase or a

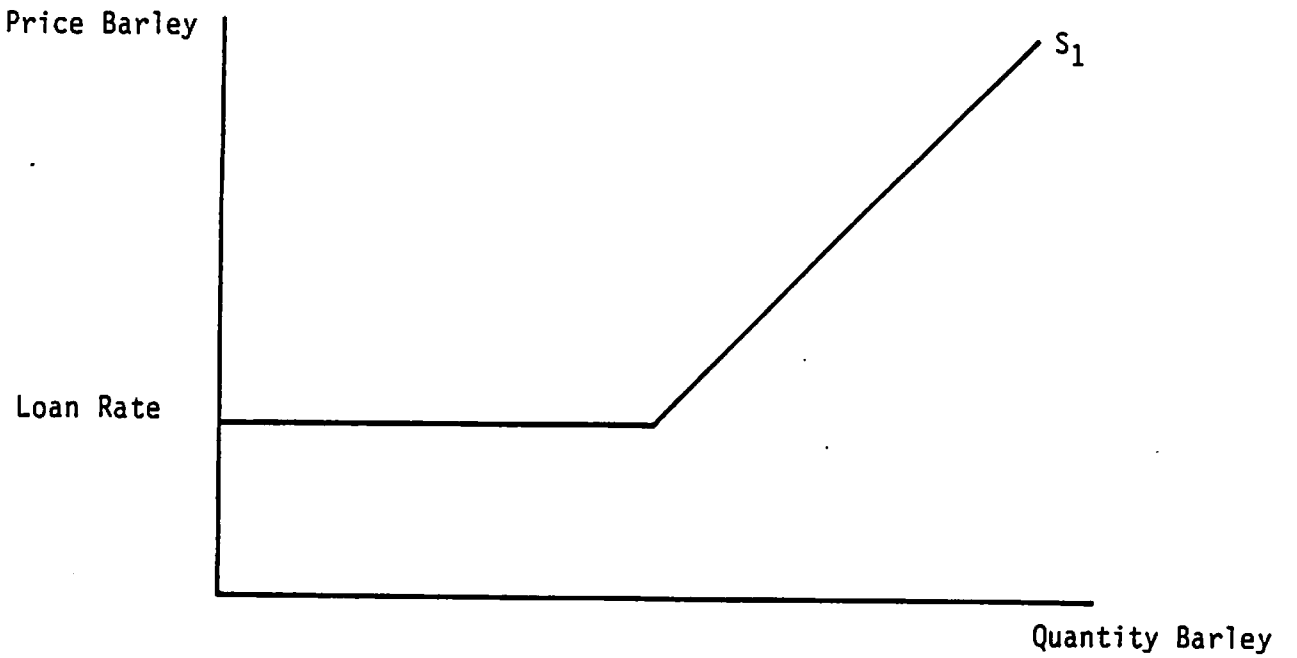

Figure 8. Hypothetical Barley Supply Curve with High Participation in the Barley Farm Program

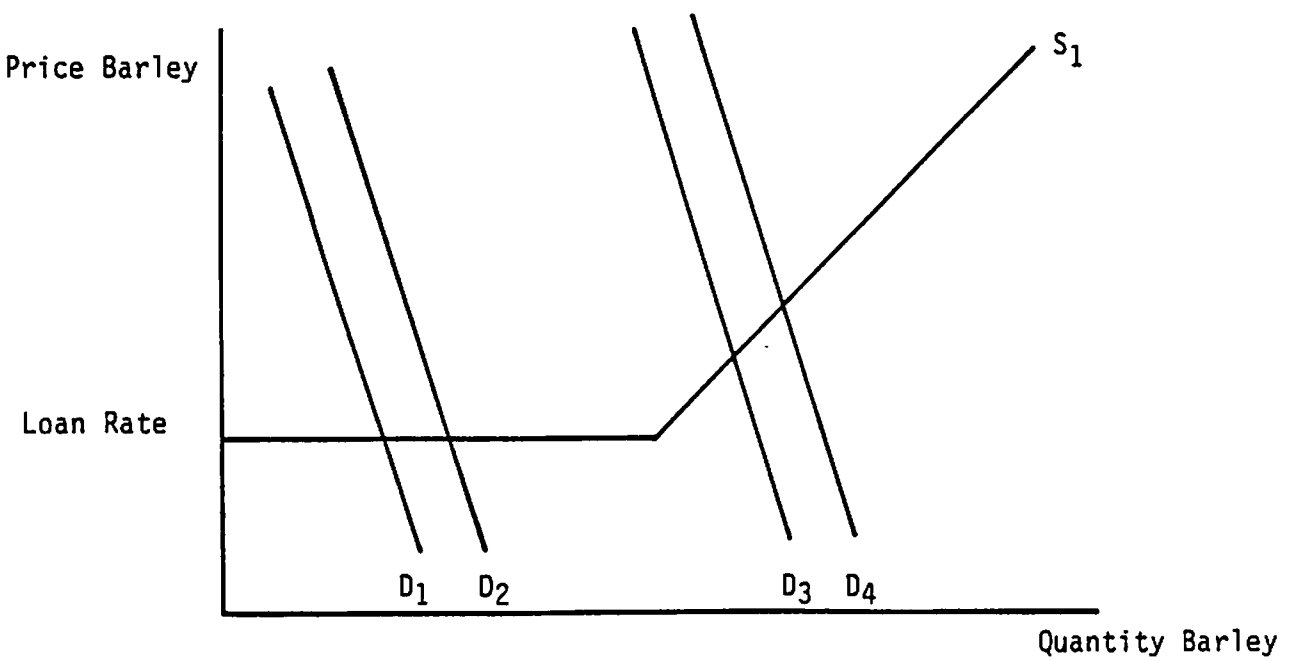

Figure 9. Changes In Demand at Points of Different Elasticities on a Barley Supply Curve Resulting From High Participation in the Barley Farm Program

decrease) would not change the price for barley. However, if the original demand curve D_3 shifts to D_4, a price increase would occur. Shifts in demand to the upward sloping portion of S_1 or a shift in demand from the horizontal to the upward sloping portion of S_1 would result in a price change. It should be noted that the effect of a government subsidy to the ethanol industry would increase the demand for barley and, thus, cause the demand curve to shift to the right.

Determining price impact using this approach requires estimates of elasticity. Elasticities of supply and demand for North Dakota barley were not available and were difficult to estimate. A hypothetical set of data for the variables was posed to give an indication of their relative sensitivity (Appendix B). The elasticity of demand for North Dakota barley is assumed to be elastic due to the government program impact and that several good alternatives (e.g., wheat) are easily substituted in production. The high degree of substitutability of other commodities leads to the conclusion that the elasticity of demand for barley is quite elastic (greater than 1.0). In reality, the barley demand curve has different elasticities of demand at different points on the curve. It also is assumed that the barley supply curve is elastic. Producers would be very responsive to small increases in price so the elasticity of supply is elastic (and assumed to be more elastic than the demand curve). Again, proving or disproving these assumptions is very difficult without extensive empirical analysis, and estimates of the elasticities of supply and demand for North Dakota barley are nonexistent.

The impact on North Dakota barley prices associated with the operation of the Walhalla ethanol plant was estimated for two sets of elasticities in the text of this report. In addition, Appendix B presents several hypothetical examples which help to illustrate the sensitivity of parameter estimates when employing the elasticity approach to estimate price changes corresponding to a shift in demand. These examples show that price impacts estimated with an elasticity approach are very sensitive to the elasticities of supply and demand, the two parameters most difficult to obtain. Widespread difference in opinion (i.e., not so much as to whether the supply and demand curves are elastic or inelastic, but to what degree) about the values of these variables can lead to disagreement in the value of estimating price impacts using the elasticity approach.

Data requirements for estimating the price impact of the Walhalla ethanol plant are much less for an elasticity approach than those for statistical modeling techniques. An elasticity analysis was performed with parameters that approximate the 1986 North Dakota situation. Barley production was estimated at approximately 176 million bushels for 1986 and $1.40 per bushel is the assumed original price. Shift in demand as a result of the Walhalla ethanol plant barley purchases will be estimated at 4 million bushels (i.e., actual January through May 1986 bushels purchased plus the remaining seven months at full capacity requirements of 500,000 bushels per month). Because of the widespread difference in opinion about the elasticity of demand and supply, two scenarios will be presented; one scenario will be elastic (E_s = 2.0 and E_d = -1.5) and another very elastic (E_s = 4.0 and E_d = -3.5).

The previously derived equation states that

$$P_1 = P_o + \frac{\Delta a}{(E_s - E_d)\ \frac{Q}{P_o}}$$

where

P_1 = new price
P_o = old price.
Δa = change in demand
E_s = elasticity of supply
E_d = elasticity of demand
Q = quantity

Results of this analysis indicate a price impact of nine-tenths of $.01 for Scenario I to four-tenths of $.01 for Scenario II (Table 18). This impact would be on the North Dakota barley market for 1986. Price impacts estimated using the elasticity approach may not appear to be very large, but it should be remembered they apply to the states' entire barley crop for a year of high production, and at a time of record surpluses and low prices. Price impacts are very sensitive to parameter changes, especially E_s and E_d, and errors in estimating these values could either increase or decrease the price impact significantly.

TABLE 18. PRICE IMPACT ASSOCIATED WITH THE CHANGE IN DEMAND RESULTING FROM DAWN ENTERPRISES' BARLEY PURCHASES, 1986

Scenario	Δa	E_s	E_d	Q	P_1	P_o
I	4,000,000	2.0	-1.5	176,000,000	1.409	1.40
II	4,000,000	4.0	-3.5	176,000,000	1.404	1.40

Economic Impact Analysis

The economic impacts associated with the operation of the Walhalla ethanol plant were analyzed using input-output analysis. Economic impact and contribution expenditures Dawn Enterprises makes in the local economy were applied to the North Dakota interdependence coefficients to estimate the associated impacts. This relationship resulted in estimates of business activity, personal income, retail trade activity, secondary employment, and selected tax revenue collections. Results will be reported as accruing in North Dakota, although the majority of the effects will be in the northeastern part of the state and more particularly in State Region 4.

Economic impacts associated with the plant are for the operational phase only, even though the construction (phase) of the plant also created impacts. Construction phase impacts were not included in this analysis for two reasons: (1) the intent of this research was to analyze the economic

impacts for 1986 and thus provide an indication of the firm's annually recurring benefits to the economy, and (2) local construction phase expenditures data were not readily available.

Input-Output Model

Describing economic impact and contribution analyses is beneficial before describing the methodology employed in a study of these types. Economic impact differs from economic contribution in that an impact analysis shows the effects of the Walhalla ethanol plant as it currently exists relative to its absence. In other words, the impact assessment of the ethanol plant would include the net amount of local expenditures over a situation in which the plant did not exist. For the Walhalla plant this means that only the price impacts should be included with the impact expenditures, and contribution expenditures would include total grain purchase amounts. Because both of these analyses provide useful and interesting information, each will be presented in this report.

An explanation of the effect that expenditures of an individual firm or industry in an area will have on the economic unit in terms of economic variables (i.e., personal income, retail trade activity, and total business activity) is termed an economic impact analysis. Gathering local expenditures from the Walhalla ethanol plant was the first step necessary to perform the impact assessment. These expenditures were applied to the North Dakota input-output model to determine the impact the Walhalla ethanol plant makes to the state's economy. This analysis will measure the additions to the state's economy in terms of total business activity, personal income, and retail trade activity as well as secondary effects including employment and tax revenue collections. The analysis will be in terms of current year (1986) dollars because expenditures were in terms of that year's dollar value.

Economic impact and contribution analysis requires choosing a technique for estimating the indirect and induced effects of an industry on economic activity, employment, and income. Input-output (I-O) analysis was selected as the economic assessment framework for the Walhalla ethanol plant because it provides more detailed estimates (i.e., business volume and employment by sector) and because I-O allows the analyst to take explicit account of differences in wage rates and local input purchasing patterns in evaluating the impacts of various development proposals (Lewis 1976; Richardson 1972).

Input-output analysis is a technique for tabulating and describing the linkages or interdependencies among various industrial groups within an economy. The economy considered may be the national economy or an economy as small as that of a multicounty area served by one of the state's major retail trade centers. An input-output model previously developed for North Dakota (Leistritz et al. 1982) has been used extensively to estimate the economic contributions of a wide range of industrial sectors. (For a complete discussion of input-output theory and methodology, as well as a review of the North Dakota input-output model, see Coon et al. [1985]).

Interdependence Coefficients

Input-output interdependence coefficients have previously been developed for North Dakota. These coefficients are commonly called multipliers because they measure the number of times a dollar of income "turns over" in the state. The multiplier effect results when each producing sector buys some fraction of its inputs from other sectors of the state's economy and these sectors, in turn, use some fraction of that income to buy some of their inputs from still other sectors, and so on. The multiplier effect is due to the spending and respending within the state's economy of part of each dollar that enters the state. Input-output interdependence coefficients for North Dakota are presented in Appendix A, Table 1. Application of the local expenditures to the respective multipliers will yield levels of business activity necessary to measure the economic impact and contribution of the ethanol plant. Because all local expenditures were in terms of current year prices, applying these values to the multipliers also yields economic assessments in similar terms.

Productivity Ratios

The ratio of gross business volume to employment, sometimes called the productivity ratio, indicates the dollar volume of business activity in a sector per worker in that sector. Productivity ratios are particularly useful when conducting economic contribution studies. When in-state expenditures for the ethanol plant are applied to the multipliers, the resultant business activity can be divided by the productivity ratios to estimate secondary (or indirect and induced) employment. Secondary employment is that which will arise as a result of the expenditures from the industry as they are spent and respent throughout the economy by the multiplier process. This employment is in addition to the workers directly employed by the industry, and essentially comes into existence to serve and supply the industry. Productivity ratios used to estimate indirect and induced workers resulting from ethanol industry expenditures are presented in Appendix A, Table 2.

Tax Revenue Estimation

Several tax revenues can be estimated using the input-output model. These include state personal income tax, corporate income tax, and sales and use tax collections. Tax revenue estimates are based on historic relationships between tax collections and input-output model estimates of gross business volume for selected sectors. Tax rates calculated were based on rates in existence in 1983 for North Dakota (Coon et al. 1984). Data were not available at this time to update the tax estimating equations to reflect the 1986 tax structures.

Estimates of state personal income tax collections were based on the following relationships:

> North Dakota personal income tax collections = 2.1 percent X personal income

Personal income from the input-output model is the total business activity of the household sector. The equation to estimate state corporate income tax is as follows:

> North Dakota corporate income tax collections = .31 percent X total business activity of all business sectors

All business sectors consist of all sectors of the economy except for the agriculture, household, and government sectors. State sales and use tax collections were estimated based on the following formula:

> North Dakota sales and use tax collections = 4.06 percent X retail trade activity

Retail trade activity is the total business activity of the retail trade sector of the input-output model. Applying these tax estimating equations to the business activity generated from the local expenditures provides tax revenue estimations for the three major North Dakota taxes.

Model Validation

Comparing personal income for the household sector of the model with estimates of personal income published by the Bureau of Economic Analysis, United States Deparment of Commerce, provides a good indication of how accurately the input-output model simulates the North Dakota economy. North Dakota personal income estimates from the input-output model have had an average deviation from Department of Commerce estimates of 5.46 percent during the 1958-1984 period. (A year-by-year comparison of the personal income estimates is presented in Appendix A, Table 3). The Theil coefficient for the state is 0.066, indicating the model is quite accurate for predictive purposes.[4]

Expenditures and Total Business Activity

Total local expenditures for operation of the Walhalla ethanol plant determine the economic impact and contribution for the facility. As previously mentioned, the additional expenditures to purchase barley above the going market rate should also be included with the impact expenditures. The reason for including only this portion of the total barley purchases is that only the additional money injected into the economy can create an impact. If the Dawn Enterprises barley market did not exist, the farmers would presumably sell their grain in other markets, or if the price was the same for all markets, they would probably be indifferent as to where their grain went;

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[4]The Theil U_1 coefficient is a summary measure, whose value is bounded by 0 and 1. A value of 0 for U_1 indicates perfect prediction, while a value 1 corresponds to perfect inequality (i.e., between the actual and predicted values). (For a further discussion of the Theil coefficient, see Leuthold [1975] and Pindyck and Rubinfeld [1981]).

thus, only prices above the going market rate would be included with the impact expenditures. However, all expenditures by the Walhalla ethanol plant (including the total amount for barley) should be included in the contribution analysis.

Difficulties in determining the price impact have been documented throughout this report, and because reliable estimates of price impacts could not be developed, price impacts are not included with the impact expenditures. To counter this problem, a transportation cost differential was estimated and included with the expenditures for the impact analysis so as to minimize any understatement of the results that may have occured by not including the price impact. Prices paid for commodities are generally the price at the terminal markets (Duluth and Pacific Northwest) less freight. This results in lower prices the greater the distance from the terminal market. However, at this time a blanket freight rate exists for eastern North Dakota to the Pacific Northwest. Introduction of a new market, such as the Walhalla ethanol plant, alters the situation of increasing freight costs as the distance from the original terminal market increases, and in fact, reduces freight costs as the distance to the plant becomes less. This results in a transportation cost saving that the Walhalla ethanol plant could use to attract barley stocks going to other markets, and so will be considered part of the plant's impact expenditures. Based on this principle, a freight differential was estimated using the average barley production density per square mile (6,961 bushels per square mile) for Cavalier and Pembina counties for the approximatly 4 million bushels purchased. The procurement radius was determined and the midpoint was multiplied by a 1/2 cent per bushel freight rate to produce a freight differential which amounted to three and one-half cents per bushel. This value was applied to the estimated 4 million bushels of barley that the Walhalla ethanol plant will purchase in 1986 and included with the plant's impact expenditures. This rough approximation of the value added to barley as a result of reduced freight costs amounted to $140,000 for Walhalla area producers. Data were not available to determine what portion of barley production in the procurement area would be attracted to the Walhalla ethanol plant, so the procurement radius may be conservative as would the resulting freight differential estimate.

Total impact expenditures for 1986 were estimated to be almost $6 million while contribution expenditures totaled almost $13 million (Table 19). The largest single impact expenditure was for payrolls (Household Sector), followed by the expenditures to the coal mining and communications and public utilities sectors (primarily for the energy required for the production process). Although barley purchases were in all likelihood the largest expense to the plant, only the price impact (or freight differential in this case) was included with their expenditures for the reasons previously discussed. As would be expected, the commodity purchases for feedstocks were the largest contribution expenditure, followed by payrolls, coal mining, and communications and public utilities.

The economic impact attributable to the Walhalla ethanol plant's expenditures included personal income of $5.4 million, retail sales activity totaling $3.7 million, and a total level of business activity of $16.2 million for 1986 (Table 20). Corresponding values for the economic contribution were

TABLE 19. ESTIMATED EXPENDITURES IN NORTH DAKOTA FOR OPERATION OF THE WALHALLA ETHANOL PLANT, BY SECTOR, 1986

Sector	Impact	Contribution
	thousand dollars	
Agriculture, crops	140	7,350
Transportation	662	662
Communications and public utilities	1,307	1,307
Retail trade	651	651
Finance, insurance, and real estate	144	144
Households	1,558	1,558
Coal mining	1,314	1,314
Total	5,776	12,986

$12.4 million for personal income, $9.5 million for retail trade activity, and total level of business activity of $42.8 million. The economic measures indicate the additions to the state's economy that have resulted from the Walhalla ethanol plant's expenditures in North Dakota. The total economic activity in North Dakota ($16,241,000 for the impact and $42,810,000 for the contribution analysis) indicates that for every dollar spent by the Walhalla ethanol plant, another $1.81 is generated in the state's economy for a total of $2.81 for the impact analysis and each contribution dollar spent generates another 2.29 for a total of $3.29.

TABLE 20. ESTIMATED PERSONAL INCOME, RETAIL SALES, BUSINESS ACTIVITY OF ALL BUSINESS (NONAGRICULTURAL) SECTORS, AND TOTAL BUSINESS ACTIVITY RESULTING FROM THE WALHALLA ETHANOL PLANT OPERATIONAL EXPENDITURES, 1986

Item	Impact	Contribution
	thousand dollars	
Personal income	5,426	12,378
Retail trade activity	3,651	9,513
Total business activity of all business sectors[a]	9,623	20,118
Total business activity	16,241	42,810

[a]Includes all sectors except agriculture (crop and livestock), households, and government.

Tax Collections

Data provided in Table 20 provided the necessary measures of business activity to estimate tax revenues generated by the Walhalla ethanol plant. Estimated tax revenues are presented in Table 21. Total tax revenues attributable to the plant's operations in 1986 were estimated to be $292,000 for the impact assessment and $708,000 for the contribution analysis. The largest source of estimated tax revenue in North Dakota was the sales and use tax collected ($148,000 and $386,000), followed by state personal income tax ($114,000 and $260,000) and state corporate income tax ($30,000 and $62,000) for the impact and contribution analysis, respectively.

TABLE 21. ESTIMATED TAX REVENUES ASSOCIATED WITH OPERATIONAL EXPENDITURES OF THE WALHALLA ETHANOL PLANT, 1986

Item	Impact	Contribution
	thousand dollars	
Sales and use tax	148	386
State personal income tax	114	260
State corporate income tax	30	62
Total	292	708

Employment

Direct employment for the production of ethanol at the Walhalla plant totaled 70 workers during full-scale operations in 1986. This level of direct employment was necessary to operate the plant on a full production basis (i.e., seven days a week, 24 hours per day). Expenditures made by the Walhalla ethanol plant also were responsible for creating secondary (indirect and induced) employment. Secondary employment associated with the ethanol plant's expenditures totaled 277 workers for the impact assessment and 641 workers for the contribution assessment (Table 22). Secondary employment was calculated using productivity ratios, as previously discussed, and should not be confused with the 70 direct employment jobs. Secondary employment is in addition to the direct employment; these jobs result from the plant's expenditures in the state's economy and are distributed throughout the state.

TABLE 22. ESTIMATED DIRECT AND SECONDARY EMPLOYMENT TOTALS FOR OPERATION OF THE WALHALLA ETHANOL PLANT, 1986

Employment	Impact	Contribution
Direct	70	70
Secondary	277	641

Conclusions

The purpose of this study was twofold; to estimate both the price and economic impacts associated with the operations of Dawn Enterprises ethanol plant at Walhalla. Several methodologies were employed to estimate the price impacts associated with the opening of the new market for North Dakota barley. Opening of the plant at Walhalla created a potential market for 6 million bushels of North Dakota barley although only 4 million were expected to be purchased in 1986 as the plant geared up to full production. Removing this quantity of barley from North Dakota and more particularly the northeastern part of the state should influence prices in that area to some degree.

Price impacts were estimated on a local basis (i.e., North Dakota as opposed to regionally or nationally) and all methodologies used in this study were consistent with this. Monthly data used in this analysis would have a smoothing effect on price impact estimates, and therefore, price impacts on a given contract (day, car, etc.) may be much greater than the data indicate. Also, the price impact would be greater on lower quality barley, such as feed versus malting quality barley, because the ethanol industry would realize no gains by using a higher quality barley in its production process.

Terminal-local market price spreads were analyzed to determine if pre- and post-operational means were significantly different for the Duluth and Pacific Northwest markets. The Duluth market had statistically significant different means but the PNW market did not; however, because of declining barley purchases by the Duluth market this price impact was not conclusive. An analysis of terminal market prices less freight and margin could not arrive at any conclusive results because of lack of data. Extremely accurate data were required for this methodology, but because of the competitive nature of the industry much of the data was unattainable. Statistical models also were developed with the secondary data that were available (i.e., the need for proprietary data was eliminated). These models could not measure the amount of the price impact with a high degree of reliability; again, data problems were the primary reason because of the very short time period the plant had been operational when the analysis was undertaken. The inability to estimate, with a high degree of reliability, the existence and magnitude of a price impact associated with the Walhalla ethanol plant does not preclude its existence, but rather points out the data problems encountered in this type of analysis.

A methodology using the elasticities of supply and demand for North Dakota barley also was included in this study. Data requirements for this analysis were relatively minor compared to the other approaches, but accurate estimates of the elasticity of supply and demand were critical to the analysis. Such estimates were difficult to obtain. Using slightly elastic supply and demand coefficients resulted in an estimated price impact of nine-tenths of a cent per bushel, while a more elastic situation reduced the impact to four-tenths of a cent per bushel. Results from this methodology are too highly dependent upon the estimates of supply and demand elasticity and should be used carefully because of the wide range of elasticities believed to exist.

Economic impacts associated with the Walhalla ethanol plant were estimated for 1986. Local impact expenditures of almost $6 million dollars generated $5.4 million in personal income, $3.7 million in retail trade activity, and a total business activity of $16.2 million. Contribution expenditures totaling almost $13 million produced personal income of $12.4 million, $9.5 million in retail trade activity, and $42.8 million of total business activity. Estimated tax collections associated with the impact and contributions of the plant's operation amounted to $292,000 and $708,000, respectively, in 1986. The plant employs 70 direct workers; another 277 indirect and induced jobs are created from the plant's operating impact expenditures, and contribution expenditures create 641 secondary jobs. For each dollar the plant spends in the state another $1.81 is generated through the multiplier process for a total of $2.81. Contribution expenditures created an additional $2.29 of business activity for each dollar spent, giving a total of $3.29.

Appendix A

APPENDIX TABLE 1. INPUT-OUTPUT INTERDEPENDENCE COEFFICIENTS, BASED ON TECHNICAL COEFFICIENTS FOR 17-SECTOR MODEL, NORTH DAKOTA REGIONS

Sector	(1) Ag, Lvstk	(2) Ag, Crops	(3) Nonmetallic Mining	(4) Const	(5) Trans	(6) Comm & Pub Util	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(9) FIRE
(1) Ag, Livestock	1.2072	0.0774	0.0445	0.0343	0.0455	0.0379	0.1911	0.0889	0.0617
(2) Ag, Crops	0.3938	1.0921	0.0174	0.0134	0.0178	0.0151	0.6488	0.0317	0.0368
(3) Nonmetallic Mining	0.0083	0.0068	1.0395	0.0302	0.0092	0.0043	0.0063	0.0024	0.0049
(4) Construction	0.0722	0.0794	0.0521	1.0501	0.0496	0.0653	0.0618	0.0347	0.0740
(5) Transportation	0.0151	0.0113	0.0284	0.0105	1.0079	0.0135	0.0128	0.0104	0.0120
(6) Comm & Public Util	0.0921	0.0836	0.1556	0.0604	0.0839	1.1006	0.0766	0.0529	0.1321
(7) Ag Proc & Misc Mfg	0.5730	0.1612	0.0272	0.0207	0.0277	0.0239	1.7401	0.0452	0.0704
(8) Retail Trade	0.7071	0.8130	0.5232	0.4100	0.5475	0.4317	0.6113	1.2734	0.6764
(9) Fin, Ins, Real Estate	0.1526	0.1677	0.1139	0.0837	0.1204	0.1128	0.1322	0.0577	1.1424
(10) Bus & Pers Services	0.0562	0.0684	0.0430	0.0287	0.0461	0.0374	0.0514	0.0194	0.0766
(11) Prof & Soc Services	0.0710	0.0643	0.0559	0.0402	0.0519	0.0526	0.0530	0.0276	0.0816
(12) Households	1.0458	0.9642	0.8424	0.6089	0.7876	0.7951	0.7859	0.4034	1.2018
(13) Government	0.0987	0.0957	0.0853	0.0519	0.2583	0.0999	0.0796	0.0394	0.1071
(14) Coal Mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(15) Thermal-Elec Generation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(16) Pet Exp/Ext	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(17) Pet Refining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gross Receipts Multiplier	4.4931	3.6851	3.0284	2.4430	3.0534	2.7901	4.4509	2.0871	3.6778

- continued -

APPENDIX TABLE 1. INPUT-OUTPUT INTERDEPENDENCE COEFFICIENTS, BASED ON TECHNICAL COEFFICIENTS FOR 17-SECTOR MODEL, NORTH DAKOTA REGIONS (CONTINUED)

Sector	(10) Bus & Pers Service	(11) Prof & Soc Service	(12) Households	(13) Govt	(14) Coal Mining	(15) Thermal-Elec Generation	(16) Pet Exp/Ext	(17) Pet Refining
(1) Ag, Livestock	0.0384	0.0571	0.0674	0.0000	0.0376	0.0251	0.0159	0.0145
(2) Ag, Crops	0.0152	0.0229	0.0266	0.0000	0.0285	0.0321	0.0062	0.0057
(3) Nonmetallic Mining	0.0043	0.0050	0.0057	0.0000	0.0032	0.0019	0.0045	0.0037
(4) Construction	0.0546	0.0787	0.0902	0.0000	0.0526	0.0328	0.1148	0.0929
(5) Transportation	0.0118	0.0100	0.0093	0.0000	0.0084	0.0048	0.0180	0.0172
(6) Comm & Public Util	0.1104	0.1192	0.1055	0.0000	0.0712	0.0378	0.0510	0.0444
(7) Ag Proc & Misc Mfg	0.0237	0.0362	0.0417	0.0000	0.0618	0.0782	0.0097	0.0089
(8) Retail Trade	0.4525	0.6668	0.7447	0.0000	0.3995	0.2266	0.1838	0.1675
(9) Fin, Ins, Real Estate	0.1084	0.1401	0.1681	0.0000	0.0771	0.0977	0.0388	0.0358
(10) Bus & Pers Services	1.0509	0.0455	0.0605	0.0000	0.0289	0.0201	0.0139	0.0127
(11) Prof & Soc Services	0.0497	1.1026	0.0982	0.0000	0.0493	0.0301	0.0210	0.0195
(12) Households	0.7160	1.0437	1.5524	0.0000	0.6666	0.3973	0.3205	0.2951
(13) Government	0.0774	0.0881	0.1080	1.0000	0.0511	0.0444	0.0280	0.0285
(14) Coal Mining	0.0000	0.0000	0.0000	0.0000	1.0000	0.1582	0.0003	0.0002
(15) Thermal-Elec Generation	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
(16) Pet Exp/Ext	0.0000	0.0000	0.0000	0.0000	0.0138	0.0084	1.0981	0.8227
(17) Pet Refining	0.0000	0.0000	0.0000	0.0000	0.0168	0.0102	0.0000	1.0000
Gross Receipts Multiplier	2.7133	3.4159	3.0783	1.0000	2.5664	2.2057	1.9245	2.5693

APPENDIX TABLE 2. GROSS BUSINESS VOLUME TO EMPLOYMENT (PRODUCTIVITY) RATIOS, BY ECONOMIC SECTOR, NORTH DAKOTA, 1958-1984

Year	(1) & (2) Ag	(3) Nonmetallic Mining	(4) Const	(5) Trans	(6) Comm & Pub Util	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(9) FIRE	(10) Bus & Pers Service	(11) Prof & Soc Service	(12) Households	(13) Govt	(14) Coal Mining	(15) Thermal-Elec Generation	(16) Pet Exp/Ext	(17) Pet Refining
1958	9,444	53,846	6,486	1,768	10,644	19,169	19,939	29,783	5,122	4,798	--	3,030	2,894	--	8,828	39,104
1959	9,290	54,330	6,259	1,687	10,035	17,659	18,451	26,617	4,597	4,304	--	2,787	2,610	--	12,611	39,692
1960	8,887	55,284	7,409	1,624	9,760	17,353	17,593	24,713	4,275	4,045	--	2,660	2,610	--	19,568	39,682
1961	9,414	52,307	7,188	1,779	10,824	18,846	18,451	25,166	4,288	4,159	--	2,729	3,403	--	23,296	41,311
1962	11,016	69,565	6,986	2,168	13,605	18,827	23,753	30,488	5,179	5,102	--	3,260	3,937	--	27,786	42,229
1963	12,872	77,981	7,999	2,344	14,551	19,251	24,422	31,894	5,361	5,161	--	3,238	3,561	--	29,850	43,706
1964	12,649	82,300	8,972	2,503	16,086	18,583	25,087	33,178	5,523	5,566	--	3,286	4,297	--	30,516	46,014
1965	15,406	71,111	9,135	2,656	16,060	19,562	25,420	32,893	5,807	5,437	--	3,169	5,190	--	27,822	50,375
1966	17,930	77,037	11,896	2,933	17,673	21,005	28,358	36,465	6,543	6,012	--	3,414	5,649	23,404	30,742	53,007
1967	18,988	78,906	12,355	2,853	16,765	21,745	27,589	33,397	6,189	5,451	--	3,086	9,855	43,298	31,613	55,263
1968	19,376	84,800	14,093	3,046	17,968	21,858	29,140	35,118	6,561	5,654	--	3,071	13,056	63,730	37,650	58,203
1969	22,584	88,235	16,356	3,428	20,153	27,370	32,433	39,220	7,325	6,322	--	3,376	13,230	59,693	29,449	61,133
1970	27,374	129,545	26,968	4,002	24,828	28,071	36,472	46,044	8,012	6,987	--	4,036	16,167	57,740	45,862	71,296
1971	28,922	106,060	16,353	3,992	24,964	29,513	36,402	45,721	7,842	6,739	--	4,096	17,647	70,281	50,458	77,777
1972	38,088	134,108	17,549	4,932	30,102	32,432	42,244	54,486	8,816	7,804	--	4,923	17,914	79,553	55,781	85,500
1973	61,728	190,625	23,762	7,042	41,942	42,699	59,244	77,240	11,984	10,545	--	7,071	18,750	68,683	64,096	92,822
1974	66,322	200,000	25,637	7,763	45,645	44,746	63,783	81,936	12,619	11,207	--	7,736	23,876	71,794	99,225	113,930
1975	59,977	171,333	21,977	7,356	44,515	36,673	56,823	72,700	11,346	10,288	--	6,932	24,413	61,676	83,949	125,870
1976	52,517	151,923	16,800	7,019	41,584	43,572	50,590	64,487	10,626	9,483	--	6,424	42,996	109,039	81,215	137,128
1977	46,259	146,583	16,377	6,615	39,361	40,263	49,143	58,964	10,220	9,038	--	6,207	42,737	129,329	66,699	147,058
1978	59,804	170,303	17,481	7,264	42,991	42,946	57,438	66,303	11,471	9,996	--	7,057	43,665	180,165	48,564	154,368
1979	70,488	192,012	20,660	7,904	45,971	48,201	62,930	72,542	12,019	11,058	--	8,013	57,794	248,913	60,578	233,696
1980	74,811	215,297	28,091	8,903	50,255	55,070	70,394	78,103	12,793	12,253	--	9,014	69,524	311,139	84,707	360,075
1981	85,034	243,533	36,367	10,977	58,170	57,768	83,851	89,267	14,125	13,439	--	10,594	67,983	282,730	134,764	618,212
1982	84,080	218,788	30,620	10,309	55,042	53,484	77,073	82,571	12,691	11,723	--	9,826	64,293	292,948	144,954	642,088
1983	93,635	240,042	31,356	11,662	64,527	58,772	87,188	92,571	14,018	12,973		11,007	77,439	327,880	195,633	586,323
1984	89,744	235,691	39,630	11,188	63,537	58,285	83,311	90,558	13,280	12,710		10,987	84,996	350,310	174,591	558,256

APPENDIX TABLE 3. ESTIMATES OF PERSONAL INCOME AND DIFFERENCES IN ESTIMATES, NORTH DAKOTA, 1958-1984 (THOUSAND DOLLARS)

Year	Department of Commerce Estimate	I-O Analysis Estimate	Percent Difference
1958	--	1,022,412	--
1959	1,008,057	978,420	- 2.94
1960	--	942,488	--
1961	--	1,011,462	--
1962	1,460,980	1,285,790	-11.99
1963	--	1,353,864	--
1964	--	1,521,191	--
1965	1,497,762	1,470,129	- 1.84
1966	1,555,539	1,662,394	6.87
1967	1,595,042	1,573,010	- 1.38
1968	1,643,964	1,684,451	2.46
1969	1,850,417	1,890,973	2.19
1970	1,913,283	2,117,319	10.66
1971	2,158,416	2,156,642	- 0.08
1972	2,676,385	2,601,416	- 2.80
1973	3,841,862	3,674,738	- 4.35
1974	3,739,859	4,104,667	9.75
1975	3,755,431	4,009,827	6.77
1976	3,828,880	3,860,970	0.84
1977	3,982,404	3,829,503	- 3.84
1978	4,798,839	4,481,331	- 6.62
1979	5,228,461	5,187,221	- 0.79
1980	5,657,789	5,390,502	- 4.72
1981	7,123,641	6,899,460	- 3.15
1982	7,306,383	6,305,332	-13.70
1983	7,936,951	7,223,150	- 8.99
1984	8,479,079	7,324,837	-13.61
Absolute Average Difference			5.47

Mean = -1.875 (S.D. = 6.626)

Theil's U_1 Coefficient = .066

Appendix B

This appendix contains additional information relating to the elasticity approach for estimating price impacts and includes (1) a more complete mathematical representation of the elasticity formula derivation, and (2) a hypothetical model to illustrate the sensitivity of parameter changes for the elasticity model. The elasticity equation derivation is a more detailed representation of the mathematical relationships presented in the text, and is intended for the technical reader. A hypothetical model set of parameters is presented along with the corresponding results. This provides the technical reader an example of how to apply the elasticity approach to a set of parameters and also presents a discussion of the sensitivity of each required input. Complete discussions are in the sections that follow.

Formula Derivation

The elasticity approach to estimating price impacts is based on the relationship that quantity supplied equals quantity demanded at equilibrium. Slope and intercept parameters can be used to estimate supply and demand equations. These equations are represented as follows:

$$Q_d = a + bP$$

where

Q_d = quantity demanded
a = intercept
b = slope coefficient
P = price

$$Q_s = c + dP$$

where

Q_s = quantity supplied
c = intercept
d = slope coefficient
P = price

At equilibrium, the quantity demanded equals the quantity supplied, and the equation can be solved for the price (P). This term will be used later to substitute into a larger equation. The equation is solved as follows:

$$Q_d = Q_s$$
$$a + bP = c + dp$$
$$a - c = dP - bP$$
$$P(d-b) = a - c$$
$$P = \frac{a - c}{d - b}$$

A shift in the parameters of the original equations would result in new Q_d and Q_s equations. They would be

$$Q_d = a + \Delta a + bP$$
$$Q_s = c + \Delta c + dP$$

where

Δa = shift in the demand intercept
Δc = shift in the supply intercept

Because Q_d equals Q_s at equilibrium, the following relationships exist:

$$Q_d = Q_s$$
$$a + \Delta a + bP = c + \Delta c + dP$$
$$a - c + \Delta a - \Delta c = dP - bP$$
$$P\,(d-b) = a - c + \Delta a - \Delta c$$

$$P = \frac{a - c}{d - b} + \frac{\Delta a}{d-b} - \frac{\Delta c}{d-b}$$

Let the P solved for in the above equation be the new price, or P_1, and the P [$P = (a-c)/(d-b)$] that was solved for earlier be the original price, or P_o; substituting these variables into the equation gives the following:

$$P_1 = P_o + \frac{\Delta a}{d-b} - \frac{\Delta c}{d-b}$$

For this analysis the change is in demand only, so the Δc term equals 0. This shortens the equation to

$$P_1 = P_o + \frac{\Delta a}{d-b}$$

It should be noted that the b and d terms in the above equation are actually the slope coefficients for the quantity demanded and quantity supplied equations. The slope coefficients are the partial derivative of quantity with respect to price. Solving for b and d can be done as follows:

$$E_d = \frac{\partial Q}{\partial P} \cdot \frac{P}{Q}$$

$$\frac{\partial Q}{\partial P} = b$$

$$E_d = b \cdot \frac{P}{Q}$$

$$b = E_d \cdot \frac{Q}{P}$$

where

E_d = elasticity of demand coefficient

$\frac{\partial Q}{\partial P}$ = partial derivative of Q with respect to P

P = price
Q = quantity

$$E_s = \frac{\partial Q}{\partial p} \cdot \frac{P}{Q}$$

$$\frac{\partial Q}{\partial P} = d$$

$$E_s = d \cdot \frac{P}{Q}$$

$$d = E_s \cdot \frac{Q}{P}$$

where

E_s = elasticity of supply coefficient

$\frac{\partial Q}{\partial P}$ = derivitive of Q with respect to P

P = price

Q = quantity

The d and b quantities, which reflect elasticity of supply and demand, can be substituted in the equation to calculate the new price as follows:

$$P_1 = P_o + \frac{\Delta a}{d-b}$$

$$P_1 = P_o + \frac{\Delta a}{E^s \cdot \frac{Q}{P_o} - E_d \cdot \frac{Q}{P_o}}$$

$$P_1 = P_o + \frac{\Delta a}{(E_s - E_d)\frac{Q}{P_o}}$$

Hypothetical Model

Appendix Table B1 illustrates how critical the elasticity estimates are to determining the new price (P_1). Case 1 used the following values: E_s = 2.5 and E_d = -1.5, P_o = 1.50, the quantity is 100 million bushels, and the change in demand is 5 million bushels. Based on these values the change in demand will result in a $.02 per bushel price impact. Reducing the quantity of barley in half (Case 2) would have a price change of only $.04 per bushel, while in Case 3 a reduction in the change in demand reduces the price change to $.01 per bushel. Lowering the original price to $1.00 per bushel decreases the price impact to $.01 per bushel (Case 4). Case 5 evaluates the price impact with inelastic supply and demand curves. Inelastic supply and demand curves give a very significant price impact ($.13 per bushel). This case illustrates the importance of distinguishing whether the E_s and E_d are in the elastic or inelastic range. Cases 6 and 7 increase the E_s and E_d coefficients with neither having a very large influence on the price change while both are in the elastic range. The remaining Cases (9 and 10) show the change in price that results from a change in E_d to an inelastic situation and the influence of a doubling of the original price. Price changes resulting from a change in demand were very large with an inelastic situation and rather modest when they were under elastic conditions. Also, the more elastic the supply and demand curves, the smaller the resulting price change with a shift in demand.

TABLE B1. HYPOTHETICAL MODEL TO INDICATE SENSITIVITY OF VARIABLES INCLUDED IN ELASTICITY APPROACH TO ESTIMATE PRICE IMPACTS

Case	Δa	E_s	E_d	Q	P_1	P_o
1	5,000,000	2.5	-1.5	100,000,000	1.52	1.50
2	5,000,000	2.5	-1.5	50,000,000	1.54	1.50
3	2,000,000	2.5	-1.5	100,000,000	1.51	1.50
4	5,000,000	2.5	-1.5	100,000,000	1.01	1.00
5	5,000,000	0.4	-0.2	100,000,000	1.63	1.50
6	5,000,000	4.0	-1.5	100,000,000	1.51	1.50
7	5,000,000	6.0	-1.5	100,000,000	1.51	1.50
8	5,000,000	2.5	-2.0	100,000,000	1.52	1.50
9	5,000,000	2.5	-0.2	100,000,000	1.53	1.50
10	5,000,000	2.5	-1.5	100,000,000	3.04	3.00

Note: The elasticity approach uses the following equation to estimate price impacts:

$$P_1 = P_o + \frac{\Delta a}{(E_s - E_d)\frac{Q}{P_o}}$$

where P_1 = new price
P_o = old price
Δa = change in demand
E_s = elasticity of supply
E_d = elasticity of demand
Q = quantity

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