FUEL ALCOHOL PLANT LOCATION IN THE PHILIPPINES

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Location theory contains two principal models. One of these emphasizes spatial cost variation, holding demand factors constant. This is the least cost approach pioneered by Alfred Weber. The other model emphasizes market demand factors assuming costs to be spatially invariant. This is the familiar central place theory traceable to Losch and Christaller. These two partial models continue to be dominant themes of location theory despite several notable attempts to formulate a general model (Isard and Greenhut).

Perhaps this is because the advantages of partial models exceed the disadvantages. The main disadvantage is the "holding constant" of variables that may be important to the subject of the investigation. The principal advantage is the ability to draw clear conclusions based on analysis of a small number of important explanatory variables. General models incorporate more variables and emphasize the interdependence of the economic system. However conclusions are difficult to obtain when several explanatory variables have conflicting impacts on the dependent variable.

Most empirical studies of manufacturing location have employed the least cost framework, for example Babcock, Kennelly, Taylor, Isard and Capron, and Lindberg. These studies have been criticized for failure to incorporate the impact of distance on demand, locational interdependence, and agglomeration economies. These are significant criticisms of studies which atempt to describe the location patterns of entire industries. However they are somewhat less important for individual plant location studies. This is because the location of other activities can reasonably be assumed to be fixed.

The objective of this paper is to present a case study of applied location economics—the optimal location of fuel alcohol plants in the Philippines.

In February 1980 the Philippine government established PNAC (Philippine National Alcohol Commission) to administer the Philippine Alcogas Plan. The principal objective of the Plan is to reduce dependency on oil imports and achieve a more favorable balance of trade. To achieve this, a 10 percent mixture of fuel alcohol (increasing to 17 percent by 1985) is blended with gasoline. The fuel alcohol is produced from domestic agricultural raw materials, primarily sugarcane. Based on a forecast of demand for gasoline, the Philippine government has determined a need for fourteen new distilleries. The study will determine the optimal plant location for one distillery with respect to a given point market and raw materials area. The methodology and conclusions are applicable to the other plants as well.

The Model

The market for the fuel alcohol is the oil refinery city of Rosario, located approximately halfway between Manila and the sugarcane producing area to the south (see Figure 1). Since sugarcane is the primary input, the possible plant locations include a number of cities in the sugarcane producing area (including three sites suggested by PNAC), the market, and other intermediate points.

A transportation cost minimizing approach is employed to determine the optimal location. This is because the circumstances of this particular case closely correspond to the assumptions of the transport cost minimization model.[1] The primary assumptions of the model are:

1. The quantity demanded at the market is fixed and known.
2. The market is a point as opposed to a spatial market.

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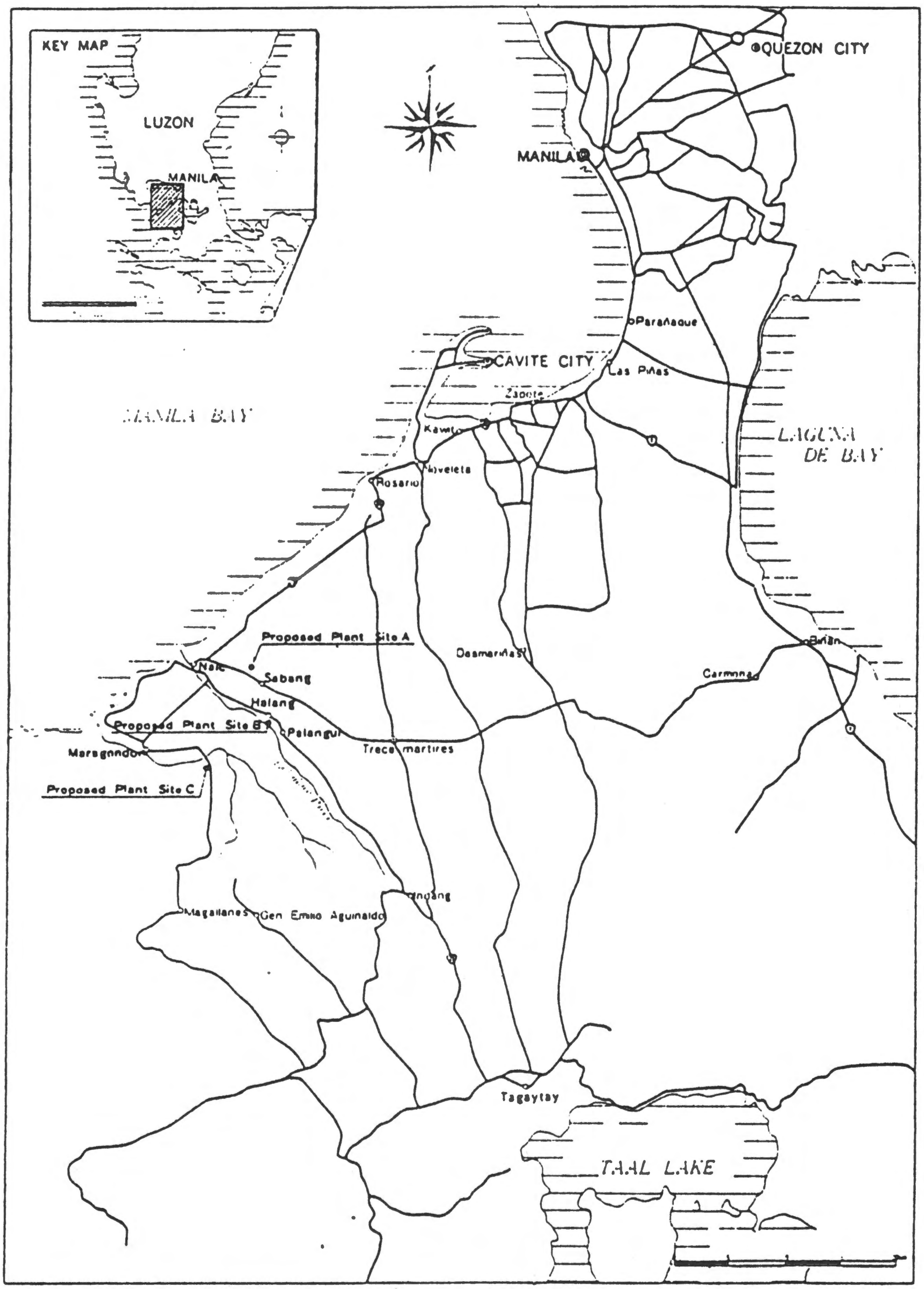

Figure 1. Location Map

3. No spatial variation in the price of non-transferable inputs.
4. The production function is a fixed coefficients production function.

In the problem at hand the quantity demanded is the given annual output of the plant and is based on a forecast of gasoline demand and proposed blending proportions of gasoline and fuel alcohol. The market is the oil refineries at Rosario rather than a spatial market. The main non-transferable inputs are energy and labor. Neither of these account for a significant proportion of production costs and there is little spatial variation in the prices of these inputs (see Table 1).

The existing technology requires a fixed amount of sugarcane input per unit of fuel alcohol. Finally there is a single point market and a single transferable input (sugarcane). Thus the circumstances of the case are nearly identical to what is commonly referred to as the "straight line location problem."

The least cost location can be determined by initially measuring the locational pulls of the market and raw material area. This can be accomplished by computing the ideal weights of the market and sugarcane area.[2] Let W_s be the number of tons of sugarcane required per ton of fuel alcohol. Also let t_s be the transport rate per ton-kilometer of sugarcane and t_a the transport rate per ton-kilometer of fuel alcohol. The ideal weights are defined as follows.

S - Ideal weight (sugarcane area) $W_s \times t_s$
M - Ideal weight (market) $1 \times t_a$

Thus if $S > M$ the locational pull of the sugarcane production area would exceed that of the market and the optimal location would be at a raw materials site. Conversely, if $M > S$ the firm would minimize transport costs at the market.

TABLE 1

Fuel Alcohol Cost Components at Optimal Location

Cost Item	Percent of Total Costs
Raw Material Acquisition	85
Raw Material Transport	7
Energy	2
Labor	5
Final Product Transport	1

If $M > S$ no further analysis is needed. However if $S > M$, the least cost site within the sugarcane production area must be determined. Based on the forecast demand for fuel alcohol and sugarcane production capacity in the area, the distillery must obtain sugercane from seven supply points. If $S > M$, each of the seven supply points, along with other sites suggested by PNAC, must be evaluated as possible distillery locations.

Evaluation of distillery locations in the raw material area involves measurement of two major transport cost components. These are the costs of assembling the necessary raw material at the plant location and the cost of shipping fuel alcohol to the market. Let the former be designated procurement cost and the latter distribution cost.

Total procurement cost (P_i) for a given plant site i is:

$$(1) \quad P_i = \sum_{j=1}^{n} (q_j)(t_s)(k_{ij})$$

i - plant site $i = 1 \ldots\ldots n$
j - raw material source $j = 1 \ldots\ldots n$
q_j - tons of sugarcane transported from raw material source j
t_s - transport rate per ton-kilometer of sugarcane
k_{ij} - distance from raw material source j to plant site i

Total distribution cost (D_i) for a given plant site i is:

$$(2) \quad D_i = (q_i)(t_a)(k_{id})$$

q_i - tons of fuel alcohol transported from plant site i
t_a - transport cost per ton-kilometer of fuel alcohol
k_{id} - distance from plant site i to demand point d

Thus the total transport cost (T_i) of any given plant site i is:

$$(3) \quad T_i = P_i + D_i$$

The Least Cost Location

Fuel alcohol is a weight losing production process requiring substantial bulk reduction of sugarcane. Thus the ideal weight of the raw material area is substantially greater than that of the market. Thirteen tons of sugarcane are

TABLE 2

Annual Sugarcane Requirements of Fuel Alcohol Distillery

Raw Material Source	Sugarcane Requirements	Percent Of Total
Trece Martires City	39,624 tons	25
Naic	2,496	2
Indang	2,080	1
Magallanes	15,600	10
Maragondon	43,680	28
GE Aguinaldo	2,600	2
Palangui	52,000	32
TOTAL	158,080	100

Source: Philippine National Alcohol Commission

required to make one ton of fuel alcohol. The transportation rates per ton-mile of input and output are .8 pesos and 1.27 pesos respectively.[3] Thus the ideal weights of the raw materials area and market are:

$$S = 13.0 \times .8 = 10.4$$
$$M = 1 \times 1.27 = 1.27$$

The least cost site within the raw material area can be determined by the procurement cost-distribution cost model. The quantities of sugarcane transported from each raw material site (q_js) were provided by PNAC. The data are based on a number of considerations. These include historical production in the area, expected demand for fuel alcohol, and input requirements for fuel alcohol production. Agronomy studies were also conducted to determine potential sugarcane output in areas not currently planted in cane. The data are in Table 2.

The quantity of fuel alcohol demanded (q_i) was also provided by PNAC. The demand is based on expected demand for gasoline and planned blending proportions of gasoline and fuel alcohol. The quantity demanded is 12,168 tons per year.

The minimum highway distances from raw material sites (k_{ij}) and the market (k_{id}) for each alternative plant site were provided by PNAC. They are in Table 3. The transport rates of input (t_s) and output (t_a) are the same as those mentioned above.

The procurement costs for each potential plant site are in Table 4. Each number in the table repreents the cost of transporting input from a given raw material source to the plant site. The transport costs in Table 4 are based on the quantities of sugarcane transported from each source (Table 2), the distances from sources to plant sites (Table 3) and the assumed transport rate of sugarcane.

The distribution costs shown in Table 5 are based on the required annual output of the plant (12,168 tons), the distances from plant sites to Rosario (Table 3), and the assumed transport rate of fuel alcohol.

The total transport costs for each raw material site and candidate sites A, B, and C are in Table 5. An examination of Table 5 reveals that

TABLE 3

Distances From Potential Distillery Sites

UNIT: KILOMETERS

	Raw Material Sources							Demand Point
Candidate Sites	Marangondon	Naic	Indang	Magallanes	Palangui	GE Aguinaldo	T. Martires	Oil Depot
Maragondon	—	10.8	36.9	21.3	18.0	19.2	30.6	35.1
Naic	10.8	—	28.8	32.1	9.9	30.0	19.8	24.3
Indang	36.9	28.8	—	55.4	18.9	31.2	20.1	45.6
Magallanes	21.3	32.1	55.4	—	39.3	7.8	53.4	56.4
Palangui	18.0	9.9	18.9	39.3	—	47.1	30.8	34.2
GE Aguinaldo	19.2	30.0	31.2	7.8	47.1	—	51.3	54.3
T. Martires	30.6	19.8	20.1	53.4	30.8	51.3	—	25.5
A	17.1	6.3	35.1	38.4	16.2	36.3	15.3	30.6
B	15.0	8.4	21.9	36.3	3.0	34.2	28.2	32.7
C	7.2	18.0	44.1	14.1	25.2	12.0	37.8	42.3

Source: Philippine National Alcohol Commission

TABLE 4

Procurement Costs of Potential Distillery Sites

Unit: Thousand Pesos

	Raw Material Sources						
Candidate Sites	Maragondon	Naic	Indang	Magallanes	Palangui	GE Aguinaldo	T. Martires
Maragondon	—	21.568	61.402	265.824	748.800	39.936	969.989
Naic	377.395	—	47.924	400.608	411.840	62.400	627.640
Indang	1289.434	57.513	—	691.392	786.240	64.896	637.150
Magallanes	744.307	64.104	92.185	—	1634.880	16.224	1692.727
Palangui	628.993	19.770	31.450	490.464	—	97.968	976.329
GE Aguinaldo	670.924	59.910	51.917	97.344	1959.360	—	1626.159
T. Martires	1069.286	39.541	33.446	666.432	1281.280	106.704	—
A	597.542	12.581	58.406	479.232	673.920	75.504	484.995
B	524.160	16.775	36.442	453.024	24.800	71.136	893.912
C	251.597	35.946	73.382	175.968	1048.320	24.960	1198.222

Naic is the least cost site. Both the distribution and procurement cost components are lower than any other site. The closest alternative, site B, is about 10 percent more costly than Naic.

Conclusion

This paper demonstrates the utility of least cost location theory when the circumstances of an actual case closely correspond to the assumptions of the model. A least cost transportation model is employed to determine the optimal plant location. Conventional methods of locational analysis are employed including ideal weights, procurement cost, and distribution cost. The conclusion of the analysis is consistent with theoretical expectations. Weight losing production processes locate close to raw materials sites.

Government subsidy of unconventional energy sources is controversial. In the late 1970s when petroleum prices were rising rapidly, many petroleum importing countries began subsidizing a variety of unconventional energy alternatives. Now that petroleum prices have leveled off these projects appear to be much less attractive.

Different countries have responded to the current situation in alternative ways. Much of the U.S. synfuels program has been indefinitely postponed. However the Philippine government has decided to continue most of its programs. Either strategy entails risk depending on the rate of future petroleum price increase. If petroleum price increases continue to abate and no oil embargoes occur, the current U.S. policy seems rational. However the opposite scenario would reward Philippine strategy.

TABLE 5

Procurement, Distribution, and Total Transport Costs Potential Distillery Sites

Unit: Thousand Pesos

Candidate Sites	Procurement Cost	Distribution Cost	Total Transport Cost
Maragondon	2107.519	541.102	2648.621
Naic	1927.807	374.609	2302.416
Indang	3526.625	702.970	4229.595
Magalannes	4244.427	869.462	5113.889
Palangui	2244.974	527.227	2772.201
GE Aguinaldo	4465.614	837.086	5302.700
T. Martires	3196.689	393.107	3589.796
A	2382.180	471.730	2853.910
B	2020.249	504.103	2524.352
C	2808.395	652.097	3460.492

FOOTNOTES

[1]For a full discussion of the assumptions and analysis of the straight line location problem see Nourse (10, pp. 74-79).

[2]For more complete discussion of the ideal weight concept see Smith (11, pp. 238-239).

[3]The transport rates provided by PNAC are truck rates. The rates were obtained from trucking cost studies. Since most trucking costs are variable, truck rates closely correspond to trucking costs. Thus the assumption of rates equal to costs is a reasonable one.

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