A SPATIAL EQUILIBRIUM MODEL OF THE CORN TRADE IN THE PHILIPPINES[1]

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ABSTRACT In this study the corn trade in the Philippines is examined using a spatial equilibrium framework in an attempt to quantify the effects of simulating an improvement in the flow of corn within the Philippines. In the analysis trade flows between the spatially and temporally separated markets are quantified. In addition, the implications of processing corn in the southern producing region of Mindanao are discussed and the effects on producers and consumers surplus determined. Central to this study is the partial comparison of transporting unprocessed and processed corn and the change this has on the economic welfare of both producers and consumers. Supply and demand functions are derived for two time periods using estimates of elasticities from various secondary sources. It was found that inter-regional and inter-temporal trade between the regions, along with producers and consumers surpluses, would increase if it were possible to process and transport corn. It is concluded that the processing of corn in Mindanao is warranted if the proper infrastructure and government policies are in place.

1. INTRODUCTION

Corn, which in the Philippines is used for human consumption, stockfeed and industrial purposes, is the second most important agricultural crop in that country because of its economic and political impact on the farming sector and the food and livestock industries. There are, however, several major problems associated with the industry which include inconsistencies in supply and demand, inadequate post-harvest (processing) facilities and an inefficient distribution system. The challenge facing policy-makers is to balance the highly seasonal and spatially dispersed domestic production of corn with the stable year round demand.

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Many of the difficulties arise because of the geographically dispersed supply and demand areas and the shortage of domestic supply during the lean months relative to demand. Currently, the island of Mindanao, in the south of the country, is the major producer. In 1990 approximately 3200,000 tonnes of corn were grown there, whilst only 297,000 and 220,000 tonnes were produced on the northern islands of Cebu and Luzon respectively. Demand for yellow corn for livestock industries comes mainly from Central Luzon, Southern Tagalog, Metro Manila and neighbouring regions on Luzon island in the north, whilst demand for white corn for food comes mainly from Cebu, an island in the middle of the country. In 1990 domestic consumption in the National Capital Region (NCR), which is a central area on Luzon, and in Cebu were 1286,000 and 352,000 tonnes respectively, while on Mindanao, 966,000 tonnes were consumed. (IFPRI, 1992; Lebrero *et al.*, 1992).

Ideally, the seasonality of supply should match the regularity of a year-round demand for corn. Supply, however, is greatest during the peak harvest months of July to December and corn deteriorates quickly if not processed. As post-harvest facilities are inadequate, large quantities cannot be stored for consumption during the lean periods and in some cases there are significant losses due to deterioration and waste. This is particularly evident in the southern producing regions where few processing facilities exist.

The internal corn trade in the Philippines suffers from several distinct disadvantages. Firstly, most of the processors (feed millers and manufacturers) as well as most commercial livestock farms are concentrated in consumption rather than production regions. In the NCR in 1987, the feed milling capacity to corn production ratio was approximately 8:1, while the ratios for Mindanao and Cebu were approximately 1:2 and 3:11, respectively (IFPRI, 1992).

Secondly, as the country is an archipelago, the cost of transporting corn from a producing island to a consuming one is high.

Lastly, grossly inefficient transport and handling facilities in producing areas often lead to market gluts in the southern producing regions on Mindanao, while supplies are tight in the northern consuming regions around Manilla on the island of Luzon. It is often cheaper for millers in the NCR markets to import corn from Thailand and other foreign sources than to transport corn from Mindanao (Daly, 1992).

Studies by the Presidential Task Force (1989), Cabanilla (1991), IFPRI (1992) and Drilon and Davidson (1994) have raised concerns regarding the grain distribution problem in the Philippines. Policy questions associated with this problem have been discussed, but the benefits of increasing the inter-island trade in corn have not been quantified.

In this study the corn trade in the Philippines is examined using a spatial equilibrium framework in an attempt to quantify the effects of simulating an improvement in the flow of corn within the Philippines. In the analysis, trade flows between the spatially and temporally separated markets are quantified. In addition, the implications of processing corn in Mindanao are discussed and the effects on producers and consumers surpluses determined. The questions addressed represent the first step in assessing the viability of encouraging the trade in corn within the

Philippines. The analysis is undertaken under the assumption that transport and processing facilities exist. Once the benefits of this trade are calculated, they can be compared in a later study with the costs of developing these facilities.

2. THE ANALYTICAL FRAMEWORK

The analysis undertaken in this study is based on a spatial equilibrium model which is the framework used for investigating trade patterns between spatially and temporally separated markets. It will enable the optimum trading pattern to be determined, given supply and demand conditions within each region. The model is useful in analysing interregional price relationships and trading patterns where there are numerous producing and consuming regions. The same logic underlies the analysis of intertemporal differences (Tomek and Robinson, 1990). Production and consumption points are linked through the arbitration of traders. Inter-regional trading is assumed to occur if regional price differences exceed the cost of moving products between regions. In a similar vein, inter-temporal trade occurs if the cost of storing a product over a set period of time is less than the price difference between the two periods. The efficiency of arbitrage between markets and over time ensures that prices between trading regions or in different seasons are aligned, after the cost of transportation and the cost of storage are accounted for (Drilon and Davidson, 1994). The welfare effects can be analysed using the 'net social payoff' concept developed by Samuelson (1952).

Details of the spatial and temporal framework used in this paper can be found in many studies; see for example Martin (1981), Labys *et al.* (1989), Tomek and Robinson (1990), and Drilon and Davidson (1994).

3. REACTIVE PROGRAMMING

An efficient and flexible technique for solving spatial and temporal equilibrium problems is reactive programming (Labys *et al.*, 1989). Seale and Tramel (1967) developed a model using reactive programming in which the simultaneous calculations of the equilibrium production and consumption levels along with the flows among regions could be undertaken. Using Seale and Tramel's model it is possible to provide a solution for the optimum quantities to be produced and consumed in each market under consideration as well as the amount which can be stored for latter periods. It is also possible to solve problems with fixed supplies, with a variety of different functional forms or with markets which exhibit seasonality of production or production costs.

In this analysis, the simulation model developed by King and Ho (1972) is used. The operation of the algorithm starts with the initial set of supply and demand equations specified in linear form. A market price is calculated from the demand function for each consuming area. By subtracting the transfer costs from the market prices, net shipping point prices are obtained. The allocated quantities among markets are then determined, in such as way that returns are maximised. The same process is repeated for the second consuming area. The iterative routine continues

until it is not profitable for any shipping area either to change the level of output or reallocate supplies.

Simulations will also be run in order to determine the effects of processing corn in the producing regions of Mindanao. In doing so, the costs of processing will be added to the transfer costs and the storage costs. This will determine the effects on quantity traded and trade flow over time. Once the results are obtained, sensitivity analyses will be undertaken to assess the validity.

4. SIMPLIFIED DIAGRAMMATIC REPRESENTATION

The economic aspects of supplying, processing and demand for corn in the Philippines using the framework described above are best described in diagrammatic form as shown in Figure 1.

The following assumptions are made:

- there are only two markets; an exporter (Mindanao) and an importer (the NCR)
- corn is produced in Mindanao at one period and consumed in the NCR at a latter time
- the market clears and there is no wastage.

For ease of explanation in this section, it is assumed that the cost of transport is zero, although this assumption is relaxed when the analysis is undertaken.

The trade in corn commences with producers in Mindanao whose production decisions are embodied in the supply schedule S_{rm}. The producers have two choices. First, they could sent their unprocessed corn to the NCR for processing. This set of circumstances is most representative of the current situation. In Figure 1 the raw market is shown in the bottom half of the three supply and demand diagrams and is designated by the subscript r. Second, they could process the corn on Mindanao and export it to the NCR in processed form. This scenario involves production in each separate region as shown in the top half of Figure 1. Each of these alternatives is presented below.

Producers on Mindanao would export unprocessed corn to the NCR if they could receive a higher price in the NCR than on the local market. The quantity they will ship to the NCR can be specified by the excess supply schedule for raw corn (ES_r) which is equivalent to the local supply (S_{rm}) less the local demand (D_{rm}), for each price level above the local raw corn price (P'_{rm}). On the other hand, the demand for imported raw corn from Mindanao can be specified by an excess demand schedule (ED_r), which is equivalent to the demand from the NCR (D_{rl}) less the NCR supply (S_{rl}) for each price level below that markets price (P'_{rl}). Observing just the raw corn market, corn is therefore traded between the two regions at price P_r with X_{rm} - Y_{rm} being exported and the equivalent amount Y_{rl} - X_{rl} being imported. The corn (Y_{rl}) is then processed in the NCR.

The economic decisions of processors in the NCR are embodied in the demand schedule D_{pl}. Both S_{rl} and D_{pl} are primary schedules and can be used to determine the derived supply and demand schedules for processed and raw corn in the NCR (i.e., S_{pl} and D_{rl} respectively). All four of these schedules can be used to determine the price of raw and processed corn which, if it is assumed that there is no trade

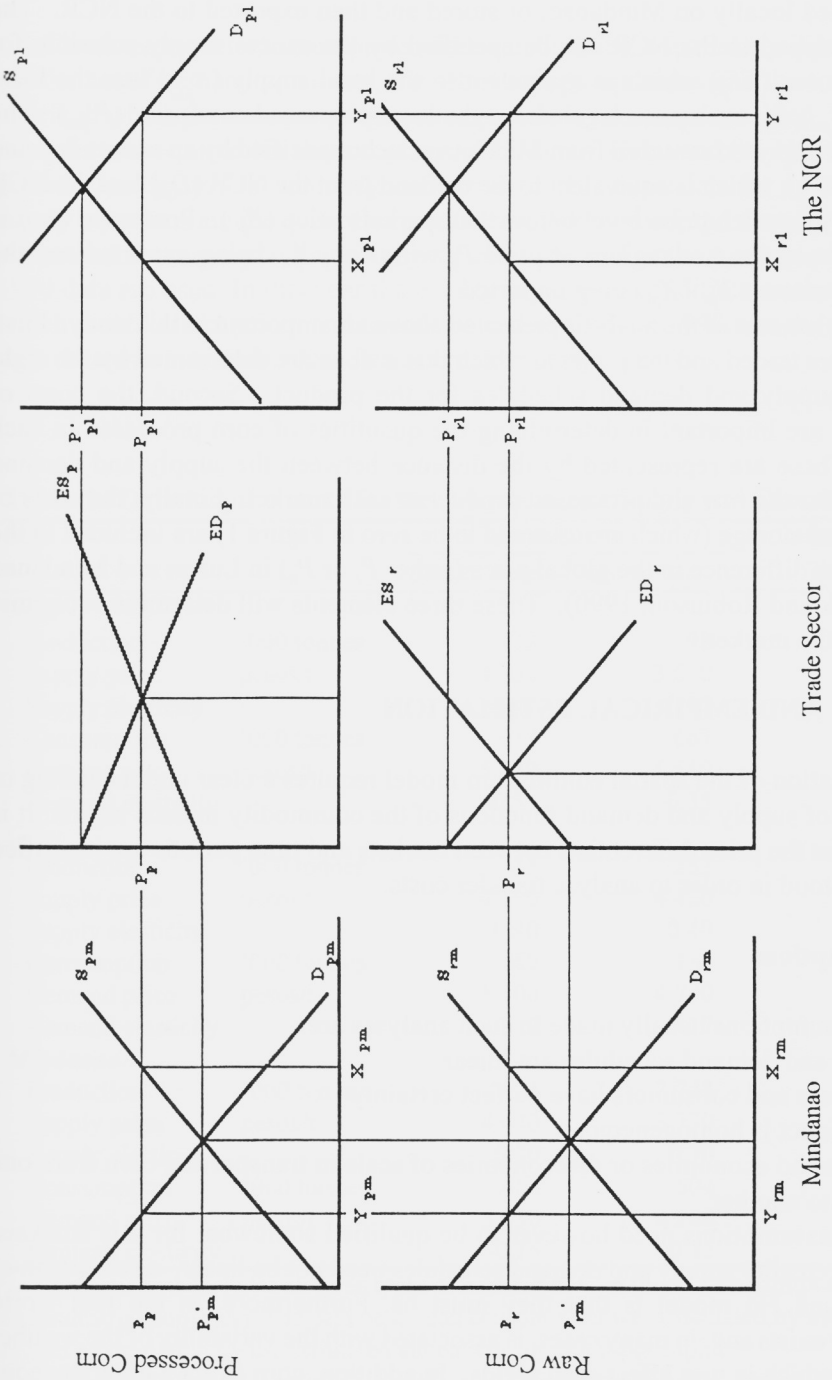

Figure 1. The Philippine Corn Trade

between the regions, would be P'_{rl} and P_{pl} respectively. The difference between these two prices is equal to the cost of processing corn in the NCR.

If however Mindanao producers process the corn, the analysis is still similar to that specified above. The demand schedule *is* D_{pm}. After processing, the corn could be consumed locally on Mindanao, or stored and then exported to the NCR. The quantity shipped to the NCR can be specified by the excess supply schedule for processed corn (ES_p) which is equivalent to the local supply (S_{pm}) less the local demand (D_{pm}), for each price level above the local processed corn price (P'_{pm}). The demand for imported raw corn from Mindanao can be specified by an excess demand schedule (ED_p), which is equivalent to the demand from the NCR (D_{pl}) less the NCR supply (S_{pl}) for each price level below that markets price (P'_{pl}). Processed corn is traded between the two regions at price P_p with X_{pm} - Y_{pm} being exported and the equivalent amount Y_{pl} - X_{pl} being imported.

Three elements of the analysis presented above are important in this study. First, the quantities traded and the prices at which this is done are determined by the eight domestic supply and demand schedules for the product. Second, the costs of processing are important in determining the quantities of corn processed in each market. These are represented by the distance between the supply and demand schedules for the raw and processed product in each market. Finally, the costs of transport and storage (which are assumed to be zero in Figure 1) are included in the model as the difference in the global price (either P_r or P_p) in Luzon and Mindanao (see Tomek and Robinson, 1990). These three elements will determine economic activity in the market.

5. DATA AND EMPIRICAL ESTIMATION

The application of the spatial equilibrium model requires a clear understanding of the nature of supply and demand functions of the commodity in each region. It is essential that the price differentials between markets and time periods are identified and understood in order to analyse transfer costs.

5.1 Assumptions

The assumptions usually made in such analyses are:

- supply and demand schedules are linear
- producers and consumers have perfect certainty
- the product is homogeneous
- there are no economies or diseconomies of scale in transporting corn from one region to another.

These assumptions need however to be qualified somewhat for this analysis. Although in reality supply and demand schedules need not be linear, a restriction of the King and Ho model is that they must be. Furthermore, in the real world uncertainty exists and, in many cases, is associated with the variability of the weather conditions which in turn affect crop yields. In addition, corn is not a homogeneous product. The importing regions in the Philippines differentiate the product into

different uses and there are different types of corn. Finally, the shipping industry, like most other enterprises, does exhibit economies of scale.

5.2 Data Requirements for the Supply and Demand Curves

The three most important prerequisites in building a spatial equilibrium model are the set of demand equations, the set of supply equations and the transfer costs matrix in which the transport, storage and processing costs are specified. Data in this analysis are required for three regions - Mindanao, Cebu and the NCR - over two periods, January to June and July to December. The basic data for the demand and supply equations are the quantities produced and consumed, the demand and supply prices and the corresponding own-price elasticities. For the purpose of this study, 1990 data are used. In this year there were no adverse conditions such as typhoons which would affect prices and quantities and in addition 1990 was the most recent year data was available. The data are presented in Table 1.

Table 1. Data Requirements for the Calculation of Supply and Demand Curves[1]

Item	Unit	Production		Information
		Jan. to June	July to Dec.	Sources
NCR				
Production	'000 tonnes	122	98	A
Supply price	pesos/t	4 230	3 670	A
Supply elasticity		0.47	0.47	B
Consumption	'000 tonnes	619	667	C
Demand price	pesos/t	5 830	5 540	A
Demand elasticity		-0.35	-0.35	B
Cebu				
Production	'000 tonnes	15	282	A
Supply price	pesos/t	4 790	4 420	A
Supply elasticity		0.40	0.40	B
Consumption	'000 tonnes	169	182	C
Demand price	pesos/t	5 100	4 740	A
Demand elasticity		-0.17	-0.17	B
Mindanao				
Production	'000 tonnes	504	2 748	A
Supply price	pesos/t	4 440	3 730	A
Supply elasticity		0.70	0.70	B
Consumption	'000 tonnes	462	504	C
Demand price	pesos/t	5 030	4 200	A
Demand elasticity		-0.15	-0.15	B

[1] This analysis includes all three types of demand of corn (human consumption, stockfeed and industrial purposes). The data on human consumption was calculated by multiplying the region's population by the estimated annual consumption per capita.

Sources: A - BAS (1993) and CRC (1994); B - Department of Agriculture; C - IFPRI (1992) and Lebrero (1992)

In the Philippines corn is demanded for human consumption, stockfeed and for industrial purposes. There is only a slight increase in the consumption of corn in the July to December period. As indicated in Table 1, the quantities consumed in the January to June period are 618,878, 169,222 and 462,150 tonnes for the NCR, Cebu and Mindanao respectively. A slight increase is noted in the July to December period with the total consumption of 667,130, 182,910 and 504,124 tonnes in the NCR, Cebu and Mindanao respectively.

Regional production data are used for estimating the supply functions with the quantities produced reported in Table 1. Mindanao is the largest producer of corn in both the periods with total production of 504,000 tonnes in January to June and 2748,000 tonnes in the July to December period.

Another essential component in estimating the structural equations are the sets of demand and supply prices. Farm-gate and retail prices of corn on a regional basis are used in this study. Monthly prices from BAS (1993) were averaged for each period. It should be noted that, because this study is only using values in 1990, year to year fluctuations in prices are not accounted for. From Table 1, it can be seen that prices are low during the peak harvest period and higher during the lean period of January to June. The seasonality of production causes the variations in prices.

The final requirement for estimating the supply and demand functions are measures of the responsiveness of the quantities produced and consumed to the changes of own-prices. Own-price elasticities are used to estimate the slope coefficients of the demand and supply functions. It should be noted that because these elasticities were estimated from different sources, they may not necessarily be consistent. The supply and demand elasticities are reported in Table 1. The demand elasticities are -0.35, -0.17 and -0.15 while the supply elasticities are 0.47, 0.40 and 0.70 for the NCR, Cebu and Mindanao respectively. Corn production in Mindanao is relatively more price elastic than in the NCR and Cebu. On the other hand, demand is more price elastic in the NCR than in Cebu and Mindanao.

Estimates of the structural parameters of the supply and demand equations are presented in Tables 2 and 3 with equations specified in the quantity domain.

Table 2. Estimated Demand Functions

Region	Slope	Intercept
January-June		
NCR	-0.003	7870.5
Cebu	-0.005	5967.0
Mindanao[1]	-0.002	5784.0
July-December		
NCR	-0.003	7479.0
Cebu	-0.004	5545.8
Mindanao[1]	-0.001	4830.0

[1] Comprising the four main regions of Mindanao, i.e., Northern Mindanao, Western Mindanao, Southern Mindanao and Central Mindanao.

Table 3. Estimated Supply Functions

Region	Slope	Intercept
January-June		
NCR	0.016	2241.9
Cebu	0.128	2874.0
Mindanao[1]	0.007	1332.0
July-December		
NCR	0.018	1975.1
Cebu	0.007	2652.0
Mindanao[1]	0.001	1119.0

[1] Comprising the four main regions of Mindanao, i.e., Northern Mindanao, Western Mindanao, Southern Mindanao and Central Mindanao.

5.3 Transportation, Storage and Processing Costs

The transfer costs matrix used in this analysis is presented in Table 4. Transfer costs include transportation, storage and processing costs. The costs of moving the commodity from the supply region i to the demand region j is given by t_{ij}. For example, the cost of shipping corn from Mindanao to the NCR is 1204 pesos (P1204) per tonne. The transport costs used are the costs of shipping from South Cotabato, which is taken to be the representative centre of the major producing region in Mindanao. In the top right quadrant of the matrix, the storage costs are added to the transportation costs. On the bottom left quadrant, the costs are set high enough to ensure that production in the peak harvest season will not be used to fulfil market requirements during the lean months season. The summary of the components of the transfer cost are shown in Table 5.

Table 4. Transfer Costs Matrix

Supply Regions	Demand Regions					
	January to June			July to December[1]		
	NCR pesos/t	Cebu pesos/t	Mindanao pesos/t	NCR pesos/t	Cebu pesos/t	Mindanao pesos/t
Jan.-June						
NCR	-	610	1,204	260	870	1,464
Cebu	610	-	1,028	870	260	1,288
Mindanao	1,204	1,028	-	1,464	1,288	260
July-Dec.						
NCR	2,000[2]	2,000[2]	2,000[2]	-	610	1,204
Cebu	2,000[2]	2,000[2]	2,000[2]	610	-	1,028
Mindanao	2,000[2]	2,000[2]	2,000[2]	1,204	1028	-

[1] Storage cost of P260 per tonne is added such that unsold product will be stored for the consumption in the next period.

[2] Costs are set high enough to ensure that production in July to December is not used to fulfil market requirements in January to June.

Table 5. The Components of the Transfer Costs

Components of the Transfer Costs	Values (pesos/tonne)
From Mindanao to NCR	
Freight	579
Handling	281
Interest and others	344
Total Costs	**1204**
From Mindanao to Cebu	
Freight	459
Handling	281
Interest and others	288
Total Costs	**1028**
From Cebu to NCR	
Freight	120
Handling	281
Interest and others	209
Total Costs	**610**
Storage Costs (3 months)	260
Processing Costs [1]	371

[1] From Quero *et al.* (1991). All others from IFPRI (1992).

The costs of storage for a three-month period is P260 per tonne. This includes the rental cost, labour, interest and shrinkage of one per cent. It should be noted that the cost of processing is the cost of milling corn into corn grits and not of the final product such as animal feed. Once corn is processed into grits it can be stored ready for mixing into animal feed. For the purpose of this study, processing costs of P371 have been added to the transportation and storage costs in Mindanao in order to determine the effects of processing on the quantity traded, traded flows and hence the net social payoff.

6. RESULTS, ANALYSIS AND IMPLICATIONS

As discussed in Section 3, the model was solved using the reactive programming algorithm developed by King and Ho (1972). Two simulations were undertaken. The first represents the current situation where there are no processing facilities in Mindanao. Consequently, as no grain can be stored there, all corn is transported to the major consumption centres, the NCR and Cebu, in an unprocessed form. Once these results were obtained, a sensitivity analysis was undertaken to assess the validity. The second simulation depicts the situation where processing in Mindanao is introduced and the processing cost is added to the transport and storage cost. This second scenario is undertaken on the assumption that facilities to process and transport corn are available. The results of the two simulations are compared and the effects on producer surplus, consumer surplus, producer revenues and consumer expenditures calculated.

6.1 Simulation 1: The Current Situation

In this simulation, the situation is considered where corn is produced in all three regions but processed only in Cebu and NCR. Supply and demand functions are calculated for each region in each period. The movement of corn from the major producing centre to the consumption centres involves a transfer cost and an additional storage cost during the peak harvest period. A perfectly competitive market is assumed and the only constraints imposed are the inter-island transfer costs and the storage costs incurred during the peak harvest season. This simulation can be considered to be representative of factors which currently exist where corn cannot be stored on Mindanao because of insufficient storage facilities and consequently the cost of storage is high.

The results of this simulation are presented in Table 6 which shows a summary of the quantities produced and consumed in each region for each period. The supply and demand price used for calculating the aggregate producer revenue and consumer outlay for each region and each time period are also reported. It should be noted that the observed price differences in some regions are indicative of the constraints placed on the supply side.

Table 6 indicates that for the January to June period, the NCR supplies and consumes 150,000 tonnes of corn and Cebu supplies and consumes 23,255 tonnes. In the same period approximately 550,000 tonnes are produced in Mindanao of which 273,011 tonnes are consumed locally and 276,988 tonnes exported to the NCR. In this solution there is no trade between Mindanao and Cebu during this period.

The peak harvest season is from July to December. From Table 6 it is observed that Mindanao is a net exporter of corn, while the NCR is a net importer. The production in the NCR region is only sufficient to meet around 10 per cent of that region's total consumption, with a total of 853,508 tonnes imported from Mindanao. The large quantity of corn needed in the NCR occurs as most of the feed manufacturers and livestock industries are situated in nearby regions. In Cebu 249,392 tonnes are produced for local consumption and 26,438 tonnes are imported from Mindanao. It should be noted that Cebu exports 49,019 tonnes to the NCR for consumption from January to June in the following year.

Hence it is implied that corn is stored in Cebu before it is shipped to the NCR. Mindanao is a net exporter and the NCR is the major importer of corn. Although Cebu imports some corn from Mindanao, the quantity is not great when compared to the quantity imported from the same source by the NCR. The main reason raw corn is not stored in Mindanao and shipped to the NCR and Cebu during the lean periods is because of inadequate storage and processing facilities.

The demand price in the NCR is higher than its supply price by P1800 per tonne. This is because of the constraint placed on the supply of corn in the region, which was imposed because of the limited capacity of the region to produce. The equilibrium prices for Cebu are P5851 and P4443 per tonne for the first and second halves of the year respectively. In Mindanao, the equilibrium price is P5182 and P3414 per tonne in the January to June and July to December periods respectively.

Table 6. Simulation 1: Corn Quantities Traded in '000s Tonnes and Prices Between Regions and Periods

Producing Area	January to June			July to December			Total Supply	Supply Price (Pesos/t)
	NCR	Cebu	Mindanao	NCR	Cebu	Mindanao		
January-June								
NCR	150						150	4,641
Cebu		23					23	5,851
Mindanao	277		273				550	5,182
July-December								
NCR				100			100	3,745
Cebu	49				249		298	4,443
Mindanao				854	26	1,416	2,296	3,414
Total Demand	476	23	273	954	276	1,416		
Price (pesos/t)	6,442	5,851	5,182	4,618	4,443	3,414		

Prices are lower during the July to December period due to the excessive supply of corn.

Sensitivity Analysis

A sensitivity analysis was carried out to test the effects of changing the major parameters in the model. The first sensitivity test was to increase the supply and demand elasticities by 50 per cent. The second sensitivity test was to increase the transfer costs by 50 per cent. The third sensitivity test was to run the model without a constraint on the quantity supply in the NCR. The effect on quantity traded and trade flow of corn from Mindanao is determined when production and supply of corn from other regions in Luzon is increased.

The results of these tests are reported in full in Villano (1994). In summary the tests found that the model is most sensitive to changes in elasticities and to changes in transfer costs. An increase in prices in the NCR was observed. Moreover, prices and quantity traded are sensitive to the level of quantity restriction in the model. The results of relaxing the constraint indicate that prices increase in the NCR and Cebu while a slight decrease is observed in Mindanao.

6.2 Simulation 2: The Effects of Processing

The aim of the second simulation is to determine the effects of processing corn in Mindanao. In doing so, a milling cost of P371 per tonne is added to the transport and storage costs. The summary of results is presented in Table 7.

In the January to June period, 150,000, 21,839 and 550,000 tonnes are produced in the NCR, Cebu and Mindanao respectively. During this period, total consumption in the NCR is 733,687 tonnes of which 583,687 tonnes are imported from Mindanao. In Cebu a total of 59,511 tonnes are consumed, of which 37,672 tonnes are imported from Mindanao.

In the July to December period, corn is processed and stored in Mindanao before it is transported to the NCR and Cebu. From the total production of 2,250,439 tonnes, Mindanao consumes 1,160,560 tonnes and 768,520 tonnes is exported to the NCR. Moreover, 583,687 and 37,672 tonnes are stored for consumption in the NCR and Cebu respectively in the January to June period of the following year. The NCR consumes 868,520 tonnes of which 100,000 tonnes are locally produced. During this period, Cebu produces and consumes 289,380 tonnes none of which are stored or shipped to other regions.

It can be seen from Table 7 that the demand price in the NCR is higher than the supply price. This is the effect of the restriction placed on the available supplies in the market. All the other prices have reached an equilibrium in supply and demand. In addition, it would appear that processing of corn in Mindanao for storage and transportation to consuming regions at other times would occur if the facilities were available. In other words, with processing, trade between regions and from one time period to another may well increase.

Table 7. Simulation 2: Corn Quantities Traded in '000s Tonnes and Prices Between Regions and Periods

Producing Area	January to June			July to December			Total Supply	Supply Price (Pesos/t)
	NCR	Cebu	Mindanao	NCR	Cebu	Mindanao		
January-June								
NCR	150						150	4,641
Cebu		22					22	5,669
Mindanao			550				550	4,684
July-December								
NCR				100			100	3,745
Cebu					289		289	4,388
Mindanao	584	38		769		1,161	2,250	3,669
Total Demand	734	59	550	869	289	1,161		
Price (pesos/t)	5,669	5,669	4,685	4,873	4,388	3,669		

Table 8. Changes in Corn Quantities Traded in '000s Tonnes and Prices

Producing Area	January to June			July to December			Total Supply	Supply Price (Pesos/t)
	NCR	Cebu	Mindanao	NCR	Cebu	Mindanao		
January-June								
NCR	no change						no change	no change
Cebu		-1					-1	-182
Mindanao	-277		+277				no change	-498
July-December								
NCR				no change			no change	no change
Cebu	-49				+40		-9	-55
Mindanao	+584	+38		-85	-26	-255	-46	+255
Total Demand	+258	+37	+277	-85	+14	-255		
Price (pesos/t)	-773	-182	-497	+255	-55	+255		

6.3 Comparative Analysis of the Two Simulations

The changes that are predicted to occur after the introduction of processing in Mindanao are presented in Table 8. Overall, the quantity traded between Mindanao and the consuming regions would increase. The predicted increases in corn received during the January to June period were 257,678, 36,255 and 276,988 tonnes for the NCR, Cebu and Mindanao respectively. In the July to December period, corn received would decrease in the NCR and Mindanao. The increase in receipts in the January to June period is greater than the decrease in receipts in the July to December period. The available supplies remain constant for some regions while supplies decreased in other regions.

Prices in the NCR, Cebu and Mindanao during the January to June period have all decreased (by P773, P182, and P449 respectively) whilst for the July to December period, an increase of P255 in the NCR and a decrease of P255 in Mindanao was predicted. The supply price in the case of the NCR remains constant, primarily because of the constraints placed on the quantity produced.

The effects on producer and consumer surplus and revenues under the two simulations are presented in Table 9. In the first half of the table, the effects on consumer and producer surplus are reported whilst in the remainder, the aggregate producer revenue and consumer outlay are detailed. With regards to economic surplus, the producer surplus is P4,622.1m for the simulation in which processing in Mindanao does not occur. In the second simulation, the producer surplus is P4,687.3m, an increase of P65.2m. On the other hand, consumer surplus is P2,941.8m in the first simulation and P3,091.5m in the second simulation, an increase of P149.7m.

Table 9. Effect on Producers and Consumers

Region	Consumer Surplus ('000 pesos)		Producer Surplus ('000 pesos)	
	Simulation 1	Simulation 2	Simulation 1	Simulation 2
January-June				
NCR	339,989	807,459	450,150	411,390
Cebu	1,349	8,855	34,616	30,525
Mindanao	82,176	302,362	1,058,750	921,937
July-December				
NCR	1,363,994	1,131,681	177,300	202,800
Cebu	152,093	167,405	267,228	250,892
Mindanao	1,002,193	673,705	2,634,056	2,869,759
Total	2,941,794	3,091,467	4,622,100	4,687,303
Net Social Benefit (Simulation 1)				*7,563,894*
Net Social Benefit (Simulation 2)				*7,778,770*
Change in Net Social Benefit				*+214,876*
		Simulation 1		*Simulation 2*
Producer Revenue		13,220,475		14,399,364
Consumer Outlay		15,079,882		16,834,633

In the January to June period, total consumer and producer surplus increased. On the other hand, in the July to December period the consumer surplus for NCR and Mindanao decreased, while that of Cebu increased. An increase in producer surplus for the NCR and Mindanao is predicted in the same period, while a slight decrease is predicted for Cebu.

The aggregate economic surplus shows that as a result of the significant increase in the quantity traded, there is an increase in both producer and consumer surplus. Overall, the net social benefit increased by P214.9m.

With regards to producer revenue and consumer outlay, the results of the first simulation indicate that both revenue and consumer outlays are lower than the predicted solution of the second simulation. Under the first simulation producers are estimated to earn P13,220.5m while consumers predicted expenditure was P15,079.9m. In the second simulation producers are expected to earn P14,399.4m in revenue, while consumers are expected to spend P16,834.6m.

7. IMPLICATIONS AND POLICY RECOMMENDATIONS

It is evident from the results that the quantity of corn traded would increase if it were possible to process corn in Mindanao. It is apparent that the total receipts for the NCR and Cebu has increased, and a significant increase in trade with the NCR is predicted. Aside from the inter-island trade of corn, a notable change in the trading pattern is predicted where corn can be stored in Mindanao before it is shipped to the NCR and Cebu during the lean months period.

An increase of P149.7m in consumers surplus and an increase of P65.2m in producer surplus is predicted with the introduction of corn processing in Mindanao. The aggregate increase in net social benefit is P214.9m. It is reasonable to conclude that processing of corn in Mindanao will increase the quantity transported to the major consumption centres, possibly leading to an increase in economic welfare.

The processing of corn in Mindanao will require an additional number of processing plants in the region. Of the total 173 registered commercial feed mills in the Philippines, only twelve are found in Mindanao (Bureau of Animal Industry, 1990). Consequently, investment on processing plants might well need to be encouraged if these benefits are to be appropriated. Policies such as tax incentives, ease of issuing licences and provision of credits will encourage investment in the establishment of processing plants.

There are also economic efficiency gains from establishing processing plants in Mindanao. These potential benefits will only be realised when better physical infrastructure facilities are linked to production points and nearest market centres. Hence investments in farm-to-market roads must be given adequate policy and funding support.

In view of the geographic dispersion between the major demand centres, the NCR on Luzon and the main supply points in Mindanao, efficient inter-island shipping and port facilities are important considerations. Reduction in trading and distribution costs can be achieved through increased efficiency in cargo handling services from open competition, as well as by accompanied investments in the port

facilities and improvement in the availability of inter-island transport vessels. (Mendoza and Rosegrant, 1992).

From the results of the sensitivity analysis it was found that the trading pattern of corn is responsive to changes in elasticities. This implies that the variability in prices will greatly affect the quantity traded. Consequently, a correction of price distortions would enhance the competitiveness and productivity of the corn sector. The government plays an important role in the responsibility to improve the public information services to ensure a timely dissemination of accurate and reliable information to farmers, consumers, millers and investors. Market information on prices, supply and demand relationships and commodity outlook will improve the options available to farmers and consumers.

The processing of corn in Mindanao also has implications for the livestock subsector. The analysis conducted by Gonzales and Perez (1992) on the structure of non-ruminant livestock production showed that feed costs contributes 65 to 87 per cent of the total farm production cost. There is a strong link between the feedgrain and livestock subsectors. As a consequence production costs of non-ruminants could be substantially reduced if efficiency in the domestic production and marketing of corn is improved. Hence, the efficiency gains as a result of processing of corn in Mindanao imply that there are also possible efficiency gains to the livestock sector.

8. SUMMARY AND CONCLUSIONS

In this study an attempt was made to model the effects of processing corn in the southern producing regions of the Philippines. The major problem confronting the Philippine corn industry is the inefficiency of transporting the commodity to the major consumption centres, the NCR and Cebu. The production of corn in the Philippines is highly seasonal. However, the use of corn as animal feed and food tends to be fairly steady throughout the year. Supply is largest during the peak harvest months, from July to December and drops during the lean periods of January to June. Coupled with the inefficiency in transport and handling facilities, the seasonality of production often leads to market gluts in Mindanao while supplies are tight in the NCR. Consequently, it is often cheaper to import corn from Thailand or other foreign sources than it is from Mindanao. The objective of this study was to ascertain the benefits of processing corn in Mindanao. Of particular interest was the implied effects to quantity traded, trade flows and economic welfare of the market participants.

It is recognised that this study is subject to a number of limitations and that the interpretations of the results must be seen within the context of these limitations. A major limitation of this study is that only the benefits from increased trade were assessed. The costs of establishing the processing and transport facilities were not assessed. Limitations also arose from the use of the spatial equilibrium model as discussed earlier. Other limitations emanate from the specification of demand and supply equations. The model only used 1990 values and hence year to year fluctuations in quantity demanded and supplied were not accounted for in the model. The elasticities used were taken from various sources and may not be consistent.

The specifications of the supply and demand functions were highly aggregated especially the case of Mindanao. Given these limitations, further research should be directed towards solving the problems inherent in them.

From the results it would appear that processing of corn in Mindanao could be warranted. If processing facilities were available, an increase in quantity traded and a consequent increase in the gains accruing to both producers and consumers might well occur. Further, there would be an inter-island and inter-temporal trade of corn. It is worth noting however, that the implied increase in efficiency would only be realised if proper physical infrastructure and policies were in place. Therefore, the government should investigate whether investment in processing plants, farm-to-market roads, and transport facilities would be feasible and review policies affecting the corn subsector.

REFERENCES

Bureau of Agricultural Statistics (BAS) (1993) *Selected Statistics on Agriculture.* Bureau of Agricultural Statistics, Quezon City.

Bureau of Animal Industry(BAS) (1990) *Data Series on Livestock Trade and Feed Production.* Department of Agriculture, Manila.

Cabanilla, L.S. (1991) *Transport of Agri-Products, Impact of Government Policies on Agricultural Transportation in the Philippines: The Case of Corn and Rice,* NEDA, Manila.

Centre for Research and Communication (CRC) (1994) *Philippine Agribusiness Factbook and Directory 1993-1994.* The Agribusiness Unit Centre for Research and Communication, Manila.

Daly, R.F. (1992) *Corn - Livestock Sector Assessment: With Analytical Applications.* Working Paper Series No. 92-01, Agricultural Policy Research Advocacy Program, Quezon City.

Drilon, M.L. and Davidson, B. (1994) Issues surrounding the establishment of feed-grain processing centres in the Southern Island of the Philippines. Paper presented to the 38th Annual Conference of the Australian Agricultural Economics Society, New Zealand, February.

Gonzales, L.A. and Perez, N.D. (1992) *The economics of hog and poultry production.* In IFPRI (1992).

International Food Policy Research Institute (IFPRI) (1992) *The Philippine Corn and Livestock Sector: Performance and Policy Implications.* APAP II Collaborative Research Report no. 328, Agency for International Development, Washington D.C.

King, R.A. and Ho, F. (1972) *Reactive Programming: A Market Simulating Spatial Equilibrium Algorithm.* Economic Research Report No.21, Department of Economics North Carolina State University Raleigh, North Carolina, April.

Labys, W.C., Takayama, T. and Uri, N. (eds), (1989) *Quantitative Methods for Market-oriented Economic Analysis over Space and Time.* Gower: England.

Lebrero, A.R., Mamon, C.R., de Jesus, C.C. and Santos, C.B. (1992) *CGPRT Crops in the Philippines: A Statistical Profile. 1960-1990,* The CGPRT Centre

Working Paper 12, Indonesia.

Martin, L. (1981) Quadratic single and multi-commodity models of spatial equilibrium: A simplified exposition. *Canadian Journal of Agricultural Economics*, 29(1), pp. 21-48.

Mendoza, M.S. and Rosegrant, M. (1992) Marketing of corn in the Philippines: Market integration and dynamics of price formation. In IFPRI (1992).

Presidential Task Force (1989) Task Force Recommendation to Support the Inter-island Shipping Industry. In *The Philippine Agricultural Development Plan 1992-1995*. Department of Agriculture, Quezon City.

Quero, R. *et al.* (1991) *The Corn Marketing System: A Rapid Marketing Appraisal in the Northern Mindanao Region.* Cagayan De Oro Chamber of Commerce and Industry Foundation, Inc., Cagayan de Oro.

Samuelson, P.A. (1952) Spatial price equilibrium and linear programming. *American Economic Review*, 42, pp. 283-303.

Seale, A.D., Jr. and Tramel (1967) Reactive programming models. In R.A. King, (ed), *Interregional Competition Research Methods,* Agricultural Policy Institute Series No.10, North Carolina State University Raleigh, Raleigh, pp. 47-58.

Tomek, W.G. and Robinson, K.L. (1990) *Agricultural Product Prices.* Cornell University Press: Ithaca.

Villano, R. (1994) *Transporting and Processing Corn in the Southern Island of the Philippines: A Spatial Equilibrium Analysis.* B.Ag.Ec.Thesis, University of New England, Armidale, Australia.