In recent years there has been rapid growth in both general deposit and private warehousing, primarily from private (i.e.,non-government) Mexican companies. An indication of growth in general deposit warehousing is conveyed by the 75 percent growth between 1989 and 1991 in the numbers of warehousing deposit certificates issued. Moreover, it should be stressed that, while the bulk of the warehouse industry falls short of U.S. standards, there exist some aggressive and rapidly modernizing firms. In addition, foreign companies, including U.S. firms such as GATX Logistics, Inc., are entering or expanding facilities in Mexico. These firms are introducing state-of-the-art technologies and will, no doubt, act as a competitive stimulus throughout the industry.

SUMMARY

NAFTA and associated measures to smooth cross-border movements will promote increased trade in produce between Mexico and the United States. NAFTA's motor carrier provisions will encourage better use of complementary movements, which, with respect to produce, will primarily benefit U.S. exporters. Trucking will remain the primary mode of transport for the foreseeable future. However, rail and marine alternatives can and should be developed to alleviate the congestion already being felt in some areas of the Mexican trucking system. Refrigerated warehousing is perhaps the most critical area needing capacity augmentation. Shortfalls in refrigerated warehousing increases product losses, promotes wasteful utilization of transport vehicles for storage, and handicaps those wishing to initiate operations, including imports, in an area.

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TRANSPORTATION MODELS: THE TREATMENT OF LOSSES IN A TROPICAL FRUIT AND VEGETABLE CASE STUDY[1]

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ABSTRACT

It is proposed a normative transportation model that incorporates the possibility of assessing losses due to the specific characteristics of the transportation system utilized, namely: the road conditions, specialized equipment and packaging patterns. An application was then developed for a cross-section of the trade of pineapples and tomatoes at a representative wholesale market from the São Paulo city in Brazil. Apart from some limitation on the data utilized, it could be observed that in an oligopolistic environment such as that, the appealing for diminishing the level of losses, via use of alternative technological options, did not appear so logical. There would be a clear benefit for the consumers, that would have an increase in the availability of those products, as well at a lower unit price. On the other hand, due to their elasticity characteristics, the producers seemed to be more sensitive to the decrease in the unit price than to the increase in the volume traded, diminishing their deliveries. The wholesalers, on their side, if keeping a fixed proportional commission on that volume received, would not be highly encouraged to invest in alternative technological options.

KEYWORDS: transport economics; post-harvest; Brazil.

RESUMEN

Se propone un modelo normativo de transporte, que incorpora la posibilidad de evaluar las pérdidas debidas a las características específicas del sistema de transporte utilizado, tales como: las condiciones de las carreteras, el uso de equipo especializado, y los patrones de empaque. Una aplicación del modelo fue también desarrollada para datos provenientes de una encuesta sobre el comércio de piñas y tomates, en un mercado mayorista representativo de la ciudad de São Paulo en Brazil. A pesar de algumas limitaciones de los datos utilizados, pudo observarse que en un ambiente oligopolista como el estudiado, la atracción por disminuir el nivel de pérdidas, via uso de opciones tecnológicas alternativas, no parece ser racional. Existiría un claro beneficio para los consumidores, porque ocurriría una mayor disponibilidad de esos productos, así como una disminución en el precio unitario. De otro lado, debido a las características de la elasticidad de esos productos, los productores parecen ser más sensibles a la reducción del precio unitario que al incremento en el volumen comercializado, disminuyendo sus entregas. Los mayoristas, por su parte, si la proporción de la comisión recibida por el volumen comercializado permanece constante, no se sentirían motivados para invertir en opciones tecnológicas alternativas.

PALABRAS CLAVE: economia de transporte; post-cosecha; Brazil.

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THE TRADE OF FRUITS AND VEGETABLES

The majority of Brazilian goods flow through the country by road transport, with the occurrence in some years of more than 90% of the agricultural production being transported by trucks. This predominance can be explained by the difficulties that the other categories of transportation systems have to respond efficiently to the transport demand increases in more interior areas, which are not necessarily well served by railways or waterways. Even though, it cannot be said that the Brazilian road transport system has achieved good rates of efficiency.

In a study developed by Farina (1993), it is shown that the road transportation time to bring melons from North of Brazil to São Paulo State was duplicated in five years, attesting the bad conditions of Brazilian roads. This can be considered a development of the same problem identified by the World Bank (Harral and Faiz, 1988), that analyzing a survey, conducted by Brazil's Federal Highway Network Authority in 1984, considered 70% of the Brazilian federal highways (more than 32,000 km) rated between fair and poor conditions, with an estimated of US$ 2.4 billion for maintenance and reconstruction work. Consequence of that, the losses in a longer journey tend to increase.

Also, as Mazaud (1994) reminds, losses during the transportation are often related to seasonal conditions. For instance, during rainy seasons, it is difficult to move produce out of the field and when it is eventually transported, many difficulties may be encountered (delays, accidents, etc.). Therefore, the neglect of road maintenance not only discourages market production but also raises transport charges and consequently consumer prices. As well, the flow of fruits and vegetables at high ambient temperature is practically unavoidable in tropical countries such as Brazil, accelerating the deterioration of those products.

The statistics about losses vary, according to the source, to the cause and to the eventual methodology to measure them. According to Borges (1992), the Brazilian situation, in terms of losses, is not different from the other developing or less developed countries. They account, in general terms, for something around 30%, achieving rates between 80 and 100% for the more perishable products, such as some fruits and vegetables. In the 1992 season, according to evaluation conducted by the Agriculture Department of São Paulo State, 11 million tones out of the national production of 34.4 million tones of fruits were wasted within the post-harvest system, implying a loss of US$ 3.3 billions. It can also be noticed that in terms of the total loss value, six products (banana, orange, grape, pineapple, tomato and mango) are responsible for more than 90% of the losses occurred in 1992.

As a mean of illustration, the trade of two of these commodities - pineapple and tomato - in the São Paulo State, is investigated, using data taken from a cross-section of the trade occurred during 1993 in the Ceagesp (*Companhia de Entrepostos e Armazéns Gerais de São Paulo*), the main wholesale market in São Paulo city, in Brazil.

The conditions for the trade of these selected commodities is basicaly determined by the wholesaler, the main actor in the entire process, who is responsible for selling the produce from the farmers. According to Barros (1990), the wholesaler lead other market levels in terms of price variations, being these variations transmitted less than proportionally to consumers and almost proportionally to producers. From the final price obtained in the market, and over the total volume delivered by the producers, the wholesalers discount their commission, as well the transport expenses (once in most of the cases they are assumed by the wholesalers themselves). The remaining value is the amount paid to the farmers.

With respect to the producers, they are usually in great number, with small properties, and with no much bargaining power over the wholesalers. Also, as Khan (1992) reminds, farmers want to be paid immediately after they deliver their products to the wholesaler. Those small farmers usually have the need of an everyday earning and do not have condition or interest to store their production.

On the other side, as transporters, the wholesalers have the interest on the storage of those products, to at least preserve the greatest amount of the products to be sold in the market. However, they are normally reluctant to incorporate some type of more advanced technology (e.g., refrigerated trucks, modified atmosphere, etc.), specially due to investment costs involved, as well to the lack of information regarding the extra returns to be obtained through the use of that type of technology. At the end, the most of the fruits and vegetables are still loaded in bulks, into normal trucks.

POLICY EXPERIMENTS

Under then a normative approach, the problem can be formulated as one of maximizing the wholesalers' surplus observed in the trade of each specific product, taking into consideration the possibility of having available supplies of technological options for diminishing losses. This would then imply the determination of: shipment patterns between supply and demand regions for agricultural products; prices to be paid to the producers; pertinent consumers' prices; and damage prediction during the transportation of each type of product. The required data are basically associated to: supply and demand functions; transport cost functions; loss functions; and the distances between the regions.

The basic differences between the scenarios to be run are related to the different transport costs involved, as well to the different level of losses to be observed. To compare the performance of refrigerated trucks over open trucks, for example, each of those logistic options was considered separately, in an individual scenario, with the different results being compared, according to the perspective of the actors involved in the process. In view of that, the following decision rules were considered:

a) the wholesalers (the main actors) would be willing to adopt an alternative logistic option if their aggregated commission is increased;

b) the consumer at the wholesale market would only be impressed by smaller unit prices;

c) the producers would be better off if their total revenue is enlarged.

The validated modeling structure was then tested under two basic types of policy experiments. In the first one, the loss function associated to the alternative transportation option was parameterized, as a mean of evaluating the principal implications on the main variables of the model. In the second category of experiment, the price elasticities were altered, with the eventual changes on the trade of the products being assessed.

Parameterizing the level of losses

Pineapples and tomatoes, if transported in the normal way have losses of 23.7% and 40%. To assess the alternative logistic options for those products, respectively "wooden boxes" and "refrigerated truck", the corresponding levels of losses were parameterized, assuming as initial levels the values of that "present behavior", to then be decreased unit by unit until reaching a minimum value of 1%. The particular behaviors of each variable being, for the tomato case, are plotted in Figures 1 and 2.

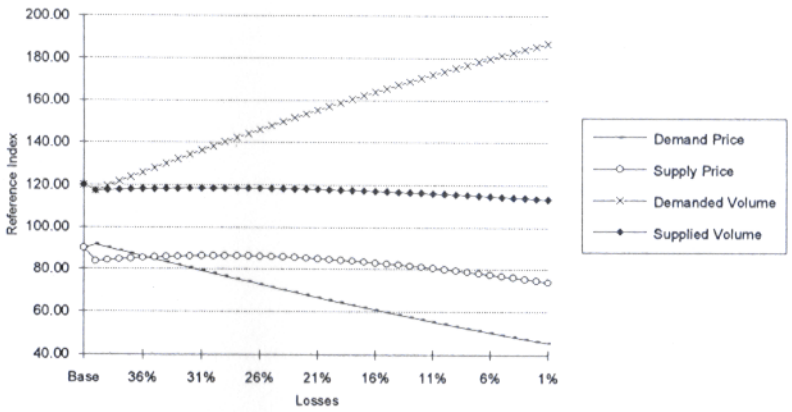

Figure 1. Supply and demand values related to tomato trade.

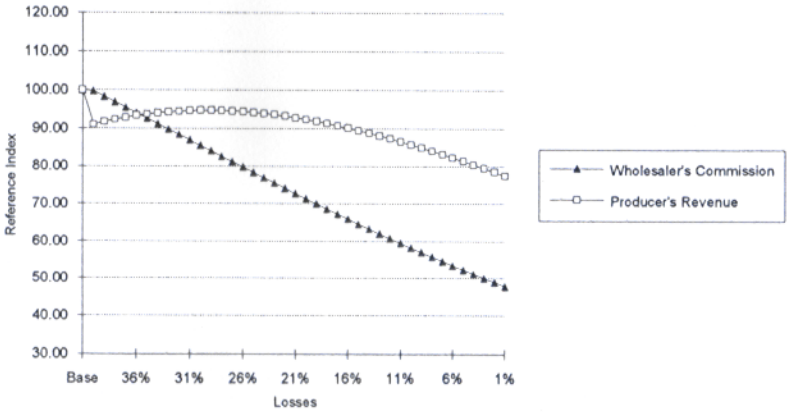

Figure 2. Wholesaler's commission and producer's revenue related to tomato trade.

Sensitivity analysis of the price elasticities

One of the main uncertainties in the set of data used in this modeling exercise is the one related to the accuracy of the price elasticities. The first deficiency, certainly, is regarding the time period that the estimates used are covering. As this type of data is rarely up-to-dated, and also because the estimation of these values would be out of the scope of this study, the only option was to use the available estimates, that were related to time periods more antique than the reference time period of the price and quantity data. To avoid then the conservative statement that the price elasticities remain the same, at least for the last fifteen years for the products selected, the possible variability of those values was assessed via sensitivity analysis.

Four scenarios were confronted with a reference scenario, with the latter being representative of the situation in which the alternative logistic option observed a level of 10% of physical losses. In the four simulated scenarios, variations of 10% in the values of the original demand and supply price elasticities were combined, with the main results for the tomato trade being presented in the Table 1.

Table 1. Results of the sensitivity analysis for the price elasticities of tomato (losses of 10% for the "refrigerated truck" option).

VARIABLE	REF. SCENARIO[a]	SCENARIO 1[b]	SCENARIO 2[c]	SCENARIO 3[d]	SCENARIO 4[e]
Dem. Price	271.85	284.23	273.28	270.47	256.73
	Δ%	4.55	0.52	-0.51	-5.56
Sup. Price	177.61	187.26	178.72	176.52	165.81
	Δ%	5.43	0.63	-0.61	-6.64
Dem. Vol.	288528.88	287016.12	282602.56	294573.04	290040.52
	Δ%	-0.52	-2.05	2.09	0.52
Sup. Vol.	320587.64	318906.80	314002.85	327303.38	322267.24
	Δ%	-0.52	-2.05	2.09	0.52
Whol. Com.	10458350.00	10877000.00	10297320.00	10622940.00	9928215.31
	Δ%	4.00	-1.54	1.57	-5.07
Prod. Reven.	56938240.00	59717350.00	56118340.00	57776810.00	53434520.00
	Δ%	4.88	-1.44	1.47	-6.15

(a) $e_s = 0.42$ and $e_d = -0.80$
(b) $e_s = 0.462$ (+10%) and $e_d = -0.88$ (+10%, in absolute value)
(c) $e_s = 0.462$ (+10%) and $e_d = -0.72$ (-10%, in absolute value)
(d) $e_s = 0.378$ (-10%) and $e_d = -0.88$ (+10%, in absolute value)
(e) $e_s = 0.378$ (-10%) and $e_d = -0.72$ (-10%, in absolute value)

Discussion of the results

From the results of the parametric analysis, it could be infered that the demand side involved in the trade of those products are much more sensitive to a decrease in losses than the supply side. It is also interesting to confirm that, for both products, the only variable that has its value clearly increased, after a decrease in the level of losses, is the "demand volume".

For the pineapple trade, the introduction of wooden boxes makes the product more attractive for the consumer, since the more availability of that fruit pressures the price down. In terms of the production side, there is almost no alteration in the behavior of the supplied volume and supply price, as well in the producer's revenue.

Consequently, the wholesaler's commission is clearly affected. With a continuous decrease per unit of loss avoided, the wholesalers are better off only until the stage in which the losses with wooden boxes are in a minimum level of 18%. Therefore, if the losses are lower than that level, even considering that this would benefit specially the consumers, it is unlikely that such logistic option be established, once the wholesalers - the main actors - would be in prejudice.

With respect to the tomato, the grounds for the viability in the utilization of refrigerated trucks are still more questionable. The transport in refrigerated trucks seems to be more attractive than the transport in open trucks, at least in terms of final demand price, when its observed level of losses becomes inferior than 38%. However, both wholesaler's commission and producer's revenue diminish continuously, after the introduction of that alternative logistic option. Therefore, it appears that both wholesaler and producer have to observe a decrease in their incomes, to pay for the increase of the benefits of the consumers.

To illustrate that, Figure 3 shows that situation "1" can be changed to situation "2" if losses incurred through transportation by refrigerated cars are diminished. The possibility of having more tomato available at the wholesale market (DV2 > DV1) pressures the price down (DP1 → DP2). The new price to be paid to the producer (SP2), is lower to the original one (SP1), what is mainly a result from the "price transmission" constraint, that searches the best combination for the difference "DP - SP". The supplied volume in the improved situation (SV2), which is also lower than the previous value (SV1), can then be calculated directly in the pertinent supply function.

Another comment is regarding the quality of the data utilized. Individually, they are certainly reliable, but when aggregated to represent the actual situation for the trade of pineapples and tomatoes, some doubts could be raised, specially with respect of the values of the price elasticities. In view of that, the sensitivity analysis conducted on those values can bring some elucidation for some preferred assumptions. The results, presented in Table 1, show that groups of variables had similar behavior - the same relative change - after the variation in the values of the elasticities: demand and supply prices; demanded and supplied volumes; and wholesaler's commission and producer's revenue. Also, due to its lower demand elasticity (in absolute value), the changes in the tomato's results were much more significant than the pineapple's ones, in either qualitative or quantitative terms.

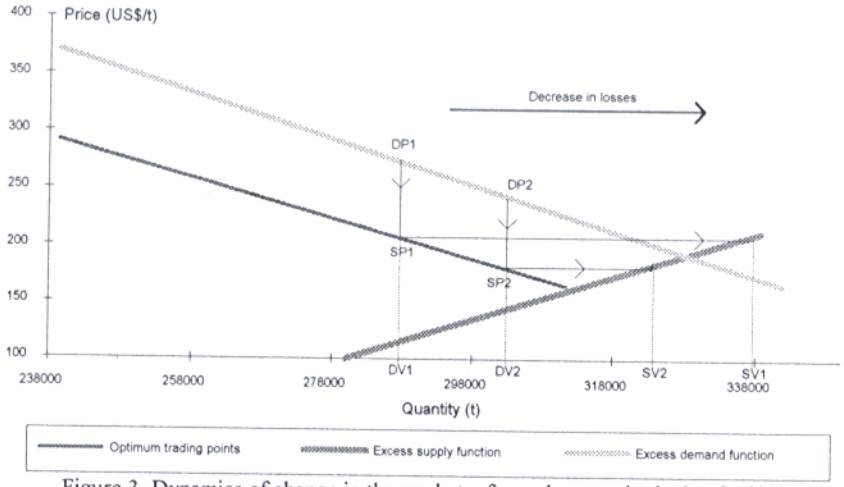

Figure 3. Dynamics of change in the market, after a decrease in the level of losses in the transportation of tomatoes.

CONCLUDING REMARKS

Reusse (1976) gives an example about the use of technology dependent on fuel-based energy, which has not necessarily led to increased productivity. The story tells about a fisherman who spends eight hours on his daily fishing trip, using sails and oars, may make the same trip in six hours if he equips his dug-out with an outboard motor. But unless the time saved is used to increase catches, the investment and operational cost of the motor must be added to the selling price of the same quantity of fish that was caught without the motor. If the time saved is used for mounting, dismounting and storing the motor, acquiring fuel, maintenance and repairs, and possibly some leisure, consumers pay more for fish and the country's balance of trade is negatively affected. Therefore, investments which merely result in the substitution of a domestic production factor by an imported one will in the long run lead to a country's loss of economic independence.

In the case study previously investigated, certainly the wholesalers must have a similar preoccupation before trying any type of investment. It is shown that, under optimal conditions of trade, the level of losses during transportation activities can be diminished. However, even considering that the wholesaler is the main actor of the process, the consumer seems to be the only recipient of benefits, what makes not very plausible to assume that the use of alternative logistic options be promoted before some other issues being discussed. The principal one is regarding the accounting for losses in the trade of agricultural products. While no more precise information about the level of actual losses - at least under the main combinations of logistic options - is available, there will be no grounds for any serious recommendation about the improvement of the transportation system upon the basis of a supposed decrease in the level of food losses.

Finally, and simply, the right transportation technology does not need to come only from expensive research efforts. It has to accomplish the contribution from all the actors involved, in the form of a positive attitude, cooperation and involvement in the importance of proper handling to save on food wastage.

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