RETURNS TO THE INTRODUCTION OF NEW SORGHUM CULTIVARS INTO THE DAIRY INDUSTRY OF EL SALVADOR

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Alexis Homero Villacís Aveiga

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Now to him who is able to do immeasurably more than all we ask or imagine, according to his power that is at work within us, to him first and above all, I would like to thank. For you Yahweh have given me the power to believe in myself and pursue my dreams. I praise God for providing me the opportunity to step in the excellent world of science and granting me the capability to proceed successfully. I could never have done this without the faith I have in you, the Almighty.

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LIST OF ABBREVIATIONS

CENTA	National Center of Agricultural and Forest Technology of El Salvador
DGEA	General Directorate of Agricultural Economics of El Salvador
FAO	Food and Agriculture Organization
INTSORMIL CRSP	The International Sorghum and Millet Collaborative Research Support Program
MAG	Ministry of Agriculture and Livestock of El Salvador
PROLECHE	National Association of Milk Producers of El Salvador
USAID	United States Agency for International Development

ABSTRACT

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The returns to the introduction of new photo-insensitive sorghum varieties into the dairy industry were analyzed to determine changes in the welfare of consumers, processors, producers and the society. The economic surplus method was used along with a survey data of a stratified sample of 150 farms conducted in 2011 in El Salvador. Results indicate that there are large returns per dollar spent and substantial benefits to consumers, processors and producers. Results also show that the adoption of these new technologies represents advantages in production costs of milk in each farm size. These cost savings per bottle are very small individually but when aggregated over the whole national milk production these are large changes and have helped keep milk prices down.

CHAPTER 1. INTRODUCTION

1.1 Background

In developing countries the share of staples, such as cereals, roots and tubers, is declining, while that of meat, dairy products and oil crops is rising (WHO, 2003, p.26). Milk, for its nutritional characteristics, provides protein, essential fats and calcium, and is considered a key consumer product worldwide. Moreover milk consumption increases rapidly with the growth of per capita income. There is a strong positive relationship between the level of income and the consumption of animal protein, with the consumption of meat, milk and eggs increasing at the expense of staple foods (WHO, 2003, p.20).

Despite being the smallest country geographically in Central America, El Salvador has the third largest economy with a per capita income of $7,600 , that is roughly two-thirds that of Costa Rica and Panama (CIA World Factbook, 2012).

Milk consumption in El Salvador, is one of the highest in Central America, with 88 Kg per year, followed by Honduras with 80 Kg and then by Guatemala and Nicaragua with a much lower consumption of 35 and 13 Kg respectively (Salvadorian Department of Economy, 2009, p.2).

In El Salvador the greatest need of the livestock farmers is to have the inputs to feed their herds, referring mainly to concentrate and natural pastures. Sorghum and maize play a major role in meeting the feed requirements of dairy cattle in most crop-livestock farming systems in El Salvador. Quantity and quality of feed heavily influence milk productivity. The feeding problem stems from the high and rising costs of concentrates and/or raw materials for its processing. In the last three decades farmers have begun to use silage as a substitute measure to reduce the high costs of concentrates.

Extension specialists from CENTA, PROLECHE and the Department of Agriculture of El Salvador have investigated the production, quality, digestibility, nutritional, and feed conversion characteristics of forage sorghum silage varieties and found that forage sorghum silage can be an attractive crop. The multiple cuts allowed often makes it preferred over corn silage. The acreage planted to sorghum silage has increased from 1,969 hectares to 20,370 hectares from 1994 to 2010.

To facilitate these consumption shifts, agricultural research led by Rene Clara of CENTA focused on the development of a series of new cultivars. CENTA and USAID-INTSORMIL have been funding this sorghum research and technology diffusion for over 11 years[1].This thesis evaluates the economic impact of this agricultural research and extension.

[1] This was complemented by extension programs for dairy of both Israeli and Japanese governments.

1.2 Problem Statement

This study attempts to answer the questions:

- Were there high social returns to the public investments in the insensitive sorghum cultivars used in dairy production in El Salvador?
- Who benefited from these investments?
- What are the effects on consumers and farmers of different sizes?

1.3 Objectives of the Study

The general objective of this study is to evaluate on the micro level the differences in feeding patterns between different farms and on the macro level the returns to society, consumers and to specific groups from the sorghum research. Specific objectives of the study are:

1. Evaluate differences in feed costs (based on sorghum and alternatives) by size of firm.
2. Estimate the returns to society from the investments in insensitive sorghum cultivars for dairy production.
3. Estimate the benefits to farmers of different sizes.
4. Make policy suggestions for research and development.

1.4 Organization of the Thesis

The thesis is organized into seven chapters. Chapter two reviews the literature on agricultural research and impact assessments. Chapter three describes the micro and macro level methodology and the data collection. Chapter four reviews the dairy sector situation and the differences between dairy production systems in El Salvador, the sorghum research program and the technologies generated by CENTA as well as the silage techniques, introduction and its diffusion. The impact analysis, benefits of the research and rates of return are presented in chapter five. Chapter six presents a sensitivity analysis along with further discussion on the effects of elasticities, processors' margins and imperfect competition. Finally chapter seven presents conclusions and policy implications of the study.

CHAPTER 2. LITERATURE REVIEW

2.1 Impact Assessments

Because resources are scarce, all governments, foreign aid donors, and private firms require accountability for the funds they invest. Especially in the public sector, agricultural research is one of the many alternatives in the investment portfolio and hence the importance of clear evidence of the returns from their investments in research. Also scientists, agricultural research centers and extension agencies use information on economic impacts to provide feedback to their research programs and to achieve the greatest possible payoffs.

By generating a better understanding of how technology influences the welfare of the different members of the society, namely producers and consumers, impact evaluation can improve targeting of research programs and help adjust resource allocation across programs (Mareida, Byerlee & Anderson, 2000).

Generally the research that generates public goods (once produced are available to everyone, especially research on staple foods) is funded by the public sector and will not benefit everyone in the same way. Moreover the economic value of public investments may not be obvious and it is difficult to observe the impact of agricultural research, because the benefits are spread over the years and for producers and consumers.

Therefore economic impact assessments are needed to measure those benefits, and compare them with the costs of the research as well as help to insure an appropriate level of public support and to attract the sustained funding research needs to be successful (Masters, 1996).

2.2 Types of Impact Assessments

Economic impact evaluations can be divided into two categories: ex-ante evaluations and ex-post evaluations. Ex-ante evaluations are undertaken before the project or program is initiated (for technologies not yet adopted) as an aid in priority setting and ex-post evaluations are undertaken after diffusion of a research product to assess actual impacts (Masters, 1996; Maredia et al., 2000).

However ex-post impact assessments, with real surveys used can be more trustworthy than ex-ante evaluations and generate information that is useful for the selection, planning and management of future research programs. These ex-post studies can be classified in partial and comprehensive assessment. Partial impact assessments quantify the application of research results but do not estimate aggregate benefits, such as adoption studies. Comprehensive impact studies look beyond adoption and measure the economic effects of the technology introduced, including the estimation of economic benefits to both producers and consumers (Maredia et al., 2000).

2.3 Impact Assessment Methods

Generally there are four broad approaches. The econometric approach, aimed at estimating productivity changes to investment in research over a time period; programming methods, aimed at identifying one or more optimal technologies or research activities from a set of options; economic surplus methods, that build benefits from the bottom up, based on estimated productivity changes at the field level and adoption rates for each technology, measuring the aggregate social benefits of a particular research project; and cost-benefit analysis, which uses the same concepts of economic surplus and calculate benefit-cost ratios to value extra output or inputs.

The economic surplus approach has been the most popular and much more widely applied in developing countries, and is the main focus of this study.

2.4 The Economic Surplus Method

Economic surplus has been the most common approach for analyzing the consequences and the welfare effects of investments in agricultural research in a partial-equilibrium framework since the early example of Griliches (1958).

This approach uses the concepts of supply, demand and equilibrium. According to Harberger (1971) when supply represents producers' production costs and demand represents consumers' consumption values, computing costs and net benefits, net changes in consumer and producer welfare may be measured using Marshallian consumer and producer surplus.

In order to calculate the returns to investment this method uses data on production affected by research, changes in production costs and yields, costs of research and development, costs of extension, adoption rates, research and adoption lags. Additionally price elasticities of demand and supply and the magnitude and nature of the supply shift play a key role in determining the distribution of the benefits gained by producers and consumers.

2.5 Effects of Elasticities on Distribution of Benefits

Elasticity assumptions do not affect total benefits, but determine to the distribution of benefits between consumers and producers. Consumers benefit more when the supply is more elastic than the demand. Producers benefit more when the demand is more elastic than the supply. For a perfectly elastic supply, all the research benefits go to the consumers, and for a perfectly elastic demand all the benefits go to producers; if both elasticities are of the same magnitude (See Figure 2.1), the benefits are distributed equally between producers and consumers (Alston, Norton & Pardey, 1998). These statements are based upon linear functions for supply and demand and assume a parallel shift[2] of the supply function.

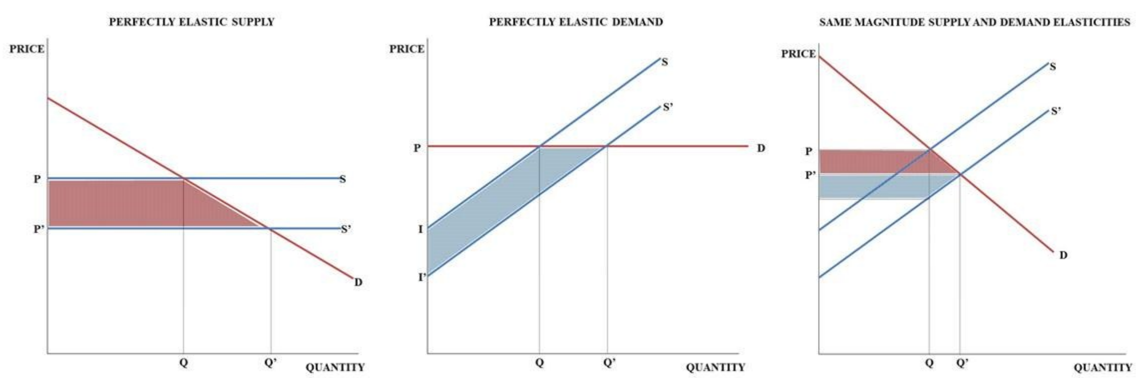

Figure 2.1 Effects of Elasticities on Distribution of Benefits

[2] Different types of supply shift can change this distribution of benefits.

2.6 Effects of Functional Forms of Supply and Demand

Assumptions of linear functions have been used by most of the authors for simplicity and because it makes it easy to calculate the areas, generated by changes in surplus, using simple algebra. As suggested by Alston and Wohlgenant (1990), the functional form of supply and demand is irrelevant when we use a parallel shift and linear functions provide a good estimate regardless of the true functional form[3] of supply and demand.

Alston et al. (1998) argues that besides being sensitive to demand and supply elasticities, the type of the research-induced supply shift also affect the economic returns. The main difference between a parallel shift and a pivotal shift is the size of total benefits, being almost twice the size when a parallel shift is used.

Producers and consumers benefit from research when a parallel shift is used (except for the cases of a perfectly elastic supply or demand), whereas with a pivotal shift producers benefit only when the demand is more elastic to the supply (Lindner and Jarret, 1978).

[3] The other principal alternative for functional forms of supply and demand is the use of constant elasticity supply and demand and is typically combined with the assumption of a pivotal supply shift where some authors have used linear approximations to calculate the changes in surplus (Ayer & Schuh, 1972; Akino & Hayami, 1995; Scoobie & Posada, 1978).

CHAPTER 3. METHODOLOGY AND DATA

3.1 Conceptual Model

Economic surplus analysis[4] compares a situation with and without the technology and can be used to quantify total increases in economic efficiency (total social benefits) as well as distribution of benefits between consumers and producers. Figure 3.1 separates the market faced by the farmers, processors and the consumers. This is a comparative-static, partial-equilibrium model of supply and demand in a commodity market in a closed economy[5]. It shows the supply curve for milk under the original technology denoted by S_f and the demand for milk at the processor (D_f) and final consumer (D_r) levels. The original price for consumers is P_r and for producers is P_f, the quantity supplied and demanded is Q and the constant per unit margin of the milk processors is M. The consumer surplus from consumption of milk is equal to the triangular area FIP_r (the area beneath the demand curve for final consumers less the price of milk); the processors surplus is equal to the rectangular area P_rIKP_f; similarly, the producer surplus is equal to the triangular area P_fKG (total revenue less total costs of production as measured by the area under the supply function).

[4] Economic surplus analysis is the most common method used for analyzing the welfare effects of agricultural research in a partial-equilibrium framework.

[5] It is a partial-equilibrium model because it focuses on part of the economy and treats most other economic variables as being constant (exogenous) in the analysis. It is a comparative-static model in that two static (single period) equilibrium situations –with and without the technology- are compared. The dynamic issue of how the new equilibrium is reached is not considered. A closed economy refers to a situation where the commodity under study is not traded internationally and its price is determined inside the country (Alston et al, 1998, p.28).

Total surplus is equal to the sum of producers, processors and consumers surplus. Changes in producer, processor, consumer, and total economic surplus are measured as changes in these areas (Alston et al., 1998, p.41).

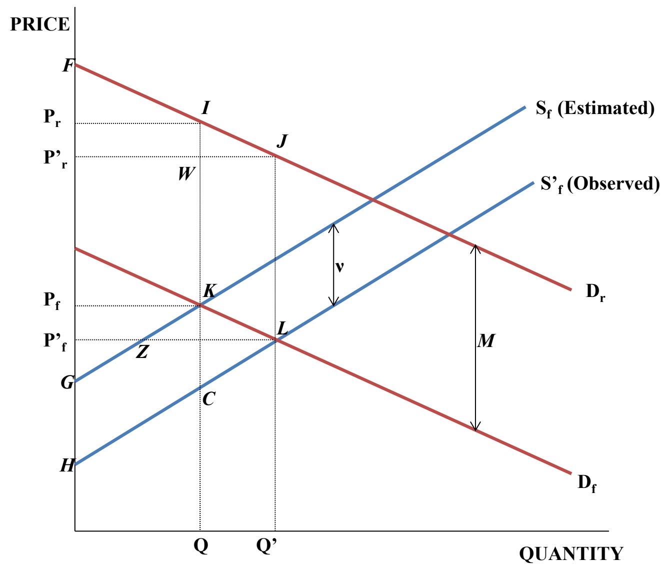

Figure 3.1 Demand and Supply of Milk with Technological Change.
Source: Adapted from Freebairn, Davis & Edwards, 1982, p. 40.

The shift of the supply curve (from S_f to S'_f) indicates the technological change from the cost reduction by using the sorghum cultivars. New quantity (*Q'*) and prices (P'_f and P'_r) result from the interaction of the supply and the demand curves. The change in consumer welfare (surplus) due to the supply shift is represented by the area $P_rIJP'_r$, the change in processors welfare (surplus) is represented by the area $P'_fLJWKP_f - P_rIWP'_r$ and the change in producer welfare (surplus) is represented by the area $HGZL - P'_fP_fKZ$. Totaling consumer, processors and producer surplus, social gains are represented by area *HGKL*[6] + *KLJI*.

[6] This area can also be interpreted as the sum of the cost savings on the original quantity (area *HGKC*) plus the economic surplus due to the increment to production and consumption surplus (the triangular area *KLC*).

Our analysis estimates the national benefits from this sorghum research [7]. Moreover, we estimate the distribution of benefits among groups, farmers, processors and consumers. Consumers gain because they consume more milk at a lower price. In general, the net welfare effect on producers may be positive or negative depending on the supply and demand elasticities and the nature of the supply shift[8]. The national or total cost savings takes the farm level savings and adjusts it by the extent of the diffusion of this technology.

This research is an ex-post study of technologies that have already been adopted and consequently the observed level of production is *Q'*. Based on this, mathematically:

- The gain for consumers is (See Figure 3.2):

$$G_c(f) = P_r IJP'_r = \text{rectangle } P_r TJP'_r - \text{triangle } ITJ = (P_r - P'_r)Q' - \frac{1}{2}(P_r - P'_r)(Q' - Q)$$

$$G_c(f) = \frac{1}{2}(Q + Q')(P_r - P'_r)$$

- The gain for producers is (See Figure 3.2):

$$G_p(f) = HGZL - P'_f P_f KZ$$

$$G_p(f) = \text{parallelogram } HGXL - \text{rectangle } P'_f P_f YL - \text{triangle } KXL + \text{triangle } KYL$$

$$G_p(f) = vQ' - (P_f - P'_f)Q' - \frac{1}{2}v(Q' - Q) + \frac{1}{2}(Q' - Q)(P_f - P'_f)$$

$$G_p(f) = \frac{1}{2}(Q + Q')[v - (P_f - P'_f)]$$

---

[7] Research benefits refer to net annual private benefits (benefits to consumers and producers).Then we will take into account the public sector costs. The difference is the benefit to the society.

[8] For this study supply and demand curves are assumed to be linear and the supply shift is defined empirically with the cost data estimated for the different farm sizes. Elsewhere we systematically evaluate the changes from different elasticities.

- The gain for processors is (See Figure 3.2):

$$G_o(f) = P'_f\, LJWKP_f - P_r IWP'_r$$
$$G_o(f) = \text{rectangle } P_f YLP'_f + \text{rectangle } KYJW - \text{rectangle } P_r IWP'_r$$
$$G_o(f) = Q'\left(P_f - P'_f\right) + \left(Q' - Q\right)\left(P'_r - P_f\right) - Q\left(P_r - P'_r\right)$$
$$G_o(f) = Q'\left(P'_r - P'_f\right) - Q\left(P_r - P_f\right)$$

- The aggregate gain for the society is (See Figure 3.2):

$$G_s(f) = G_c(f) + G_p(f) + G_o(f) = HGKIJL$$
$$G_s(f) = \left(\text{parallelogram } HGXL - \text{triangle } KXL\right) + \text{parallelogram } KLJI$$
$$G_s(f) = \left[vQ' - \frac{1}{2}v\left(Q' - Q\right)\right] + \left[\left(Q' - Q\right)\left(P'_r - P'_f\right)\right]$$
$$G_s(f) = \frac{1}{2}v\left(Q + Q'\right) + \left(Q' - Q\right)\left(P'_r - P'_f\right)$$

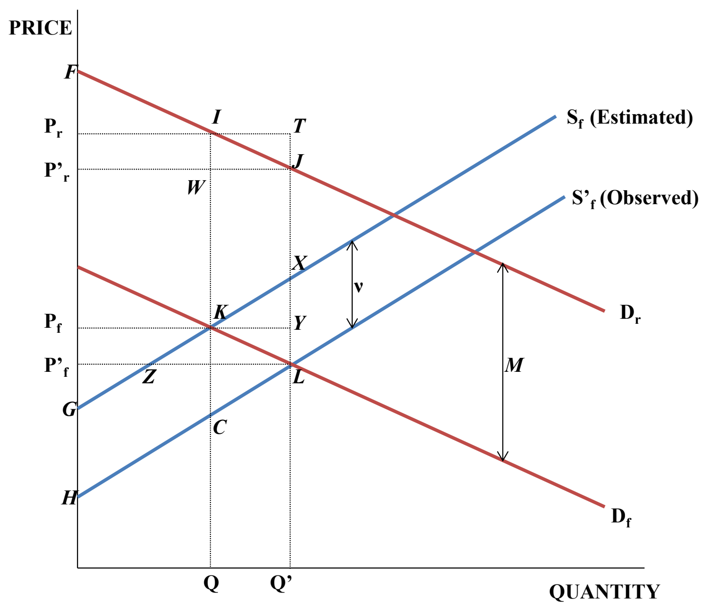

Figure 3.2 Demand and Supply of Milk with Technological Change when Observed Level of Production is Q' (ex-post study).
Source: Adapted from Freebairn et al., 1982, p. 40).

For a pivotal shift, holding the same equilibrium assumptions about the observed level of production, supply, demand, margins and the effect of a reduction in farm production costs per unit of milk output resulting from the technological change explained before, mathematically we have:

- The gain for consumers remains the same (See Figure 3.3):

$$G_c(f) = P_r IJP'_r = \text{rectangle } P_r TJP'_r - \text{triangle } ITJ = \frac{1}{2}(Q+Q')(P_r - P'_r)$$

- The gain for processors remains the same (See Figure 3.3):

$$G_o(f) = P'_f\ LJWKP_f - P_r IWP'_r$$
$$G_o(f) = \text{rectangle } P_f YLP'_f + \text{rectangle } KYJW - \text{rectangle } P_r IWP'_r$$
$$G_o(f) = Q'(P'_r - P'_f) - Q(P_r - P_f)$$

- The aggregate gain for the society now is (See Figure 3.3):

$$G_s(f) = GKIJL = (\text{triangle } GXL - \text{triangle } KXL) + \text{parallelogram } KLJI$$
$$G_s(f) = \left[\frac{1}{2}vQ' - \frac{1}{2}v(Q'-Q)\right] + \left[(Q'-Q)(P'_r - P'_f)\right]$$
$$G_s(f) = \frac{1}{2}vQ + (Q'-Q)(P'_r - P'_f)$$

- The gain for producers now is (See Figure 3.3):

$$G_p(f) = GZL - P_f P'_f\ ZK$$

Since calculating $GZL\text{-}P_f P'_f ZK$ requires the use of some unobserved data; its calculation can be represented as:

$$G_p(f) = G_s(f) - G_c(f) - G_o(f)$$

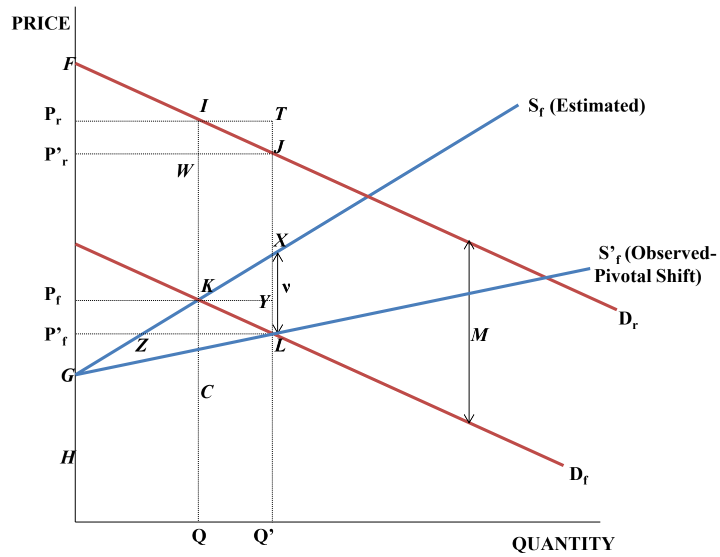

Figure 3.3 Demand and Supply of Milk with Technological Change Using a Pivotal Shift when Observed Level of Production is Q' (ex-post study).
Source: Villacís, 2012.

3.2 Sampling Method

The study was conducted in the four geographical areas in which the country is divided: Western, Central, Para-Central and Eastern, covering the fourteen departments of the country. All four have suitable agro-climatic conditions for the production of milk.

A survey design with both qualitative and quantitative aspects was used. The sampling procedure was a combination of a two-stage stratified sampling technique used to select 180 farmers for this study. In the first stage, 30 sample farmers who grew the improved sorghum varieties were selected from 4 of the 14 departments in El Salvador. In the second stage, 150 farm households were selected proportionally to the number of dairy farms per department of the sampling list. From these 150 farms, 90 farmers utilizing sorghum technologies and 60 farmers without the sorghum technologies were selected. This made a total of 120 dairy farmers who grew the improved sorghum varieties[9], and 60 who did not use sorghum[10] (See Appendix A).

The sampling list was obtained from PROLECHE and CENTA extension agencies[11] (See Figure 3.4 below). Therefore there is a bias here from the selection procedure of these two agencies for their clients.

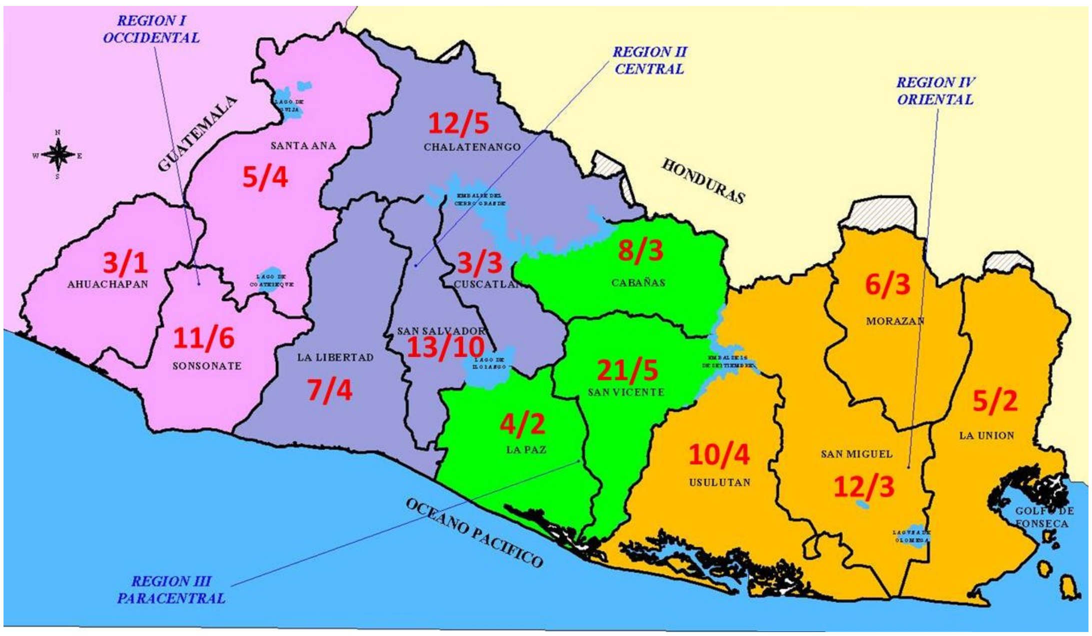

Figure 3.4 Distribution of Farmers Interviewed: With and Without Sorghum Technologies
Source: Villacís, 2011, Survey Data

The dairy farms in El Salvador are concentrated in the middle and lower part of the country, areas that have been identified as “cuencas lecheras” (milk basins). Most dairy farms are located in the departments of Sonsonate, San Vicente, Usulutan and San

[9] From these 120 farmers who used sorghum, 61 were small farmers, 44 medium farmers and 15 were large farmers.
[10] From these 60 farmers who did not use sorghum, 31 were small farmers, 22 medium farmers and 7 were large farmers.
[11] Additionally to the 180 questionnaires, there were five questionnaires that were discarded for various reasons.

Miguel (MAG, 2003, p. 14). Dairy farms in the western region (Ahuachapan, Santa Ana and Sonsonate) are characterized by greater availability of irrigation[12] and increased size of the herd while the dairy farms in the eastern region (Usulutan, San Miguel, Union and La Libertad) have a more extensive system of livestock (see Figure 3.4).

3.3 Data Collection

Sample farmers were interviewed using a designed survey questionnaire. The interviews took place at the farmer's ranches or at central meeting places when villages were inaccessible. The principal author conducted the interviews. Extension agents from CENTA and PROLECHE assisted in arranging appointments with farmers and explaining local customs and practices. A typical interview took from one to two hours. Its basic content is summarized in Table 3.1 (For the complete farm survey questionnaire see Appendix B).

Table 3.1 Structure of the Survey Questionnaire Used for the Impact Study.

Section	Content/Information
I	Demographic Characteristics of Farmers
II	Farm Assets Including Crops and Livestock
III	Production Records and Areas of Sorghum Varieties Used for Cattle Feeding
IV	Production Costs and Adoption Determinants of the New Photo-insensitive Varieties of Sorghum
V	Silage Production and Costs
VI	Cattle Feeding Costs and Milk Production
VII	Credit Service and Extension

Source: Villacís, 2011

[12] 68 out of 180 farmers interviewed had their own irrigation systems, 97 were part of irrigation cooperatives and 15 used only water from rainfalls. Feed costs differences between these systems were taken into consideration for this study and were found to be insignificant.

Both primary and secondary data were used. The primary data were collected from farm households using a structured questionnaire; these farm-level surveys were conducted to determine the differences in feeding costs among the different farm sizes. Secondary data were collected from the agricultural and related organizations operating in the area of study, namely, Ministry of Agriculture and Livestock, National Center of Agricultural and Forest Technology (CENTA), National Association of Milk Producers (PROLECHE), Department of Statistics, Ministry of Economics and the Salvadorian Central Bank. Both primary and secondary data were required to estimate the economic surplus model.

Additionally data on the annual costs of research activities on sorghum incurred by CENTA, which included generation, evaluation and land and office rentals, were obtained for the period 1993-2010. This information together with further discussions with specialists, senior scientists and administrators of CENTA led to the research cost estimates. Extension, transfer activities and associated expenses from 1993 until 2010 were estimated with the guidance of a senior extension officer from CENTA. In addition, data on extension service costs from the Israeli Cooperation over the period 1993-2004 were collected.

3.4 Empirical Model

Following Freebairn et al. (1982, p. 40) and defining the milk consumer demand as $Q_r = a - \alpha P_r$ and farm milk supply as $Q_f = b + \beta P_f$ we can calculate the benefits for consumers, producers and the society, where α is the slope of the demand function and β is the slope of the supply function. To obtain elasticity[13] estimates we used other studies on the demand and supply of milk for consumers and producers respectively; values for elasticities used in this study were 0.1 for supply and 0.2 for demand respectively (FAPRI, 2011, sec. tools elasticities database). Then slopes α and β were obtained using the elasticity values mentioned before with the annual values of prices and quantities observed[14].

The change in quantity resulting from the research ($\Delta Q = Q' - Q$) depends on the shift in the supply curve and the responsiveness of supply and demand. Recalling that the retail price equals the farm price plus the margin ($P_r = P_f + M$) the equilibrium situation without the technology shift would be that price and quantity, which satisfy both demand and supply:

$$
\begin{gathered}
Q_r = Q_f = Q \\
a - \alpha P_r = b + \beta P_f \\
a - \alpha\left(P_f + M\right) = b + \beta P_f \\
P_f = \frac{a - b - \alpha M}{\alpha + \beta}
\end{gathered}
$$

[13] Elasticities are defined as the percentage change in quantities consumed (demand) and produced (supply) in response to a one percent change in prices (consumers' and producers'), where the elasticity of supply is $\varepsilon = \beta P_f / Q$ and the elasticity of demand is $\eta = \alpha P_r / Q$.
[14] We calculated α using $\alpha = \eta Q / P_r$ and β using $\beta = \varepsilon Q / P_f$

And therefore:

$$P_r = \frac{a - b - \alpha M}{\alpha + \beta} + M$$

With research, the equilibrium now is on a new supply curve, where *v* is the shift down of supply caused by the effect of a reduction in farm production costs per unit of milk output resulting from the technological change[15]:

$$Q'_r = a - \alpha P'_r$$
$$Q'_f = b + \beta\left(P'_f + v\right)$$

Remembering again that $P'_r = P'_f + M$, the equilibrium situation with research would be:

$$Q'_r = Q'_f = Q'$$
$$a - \alpha P'_r = b + \beta\left(P'_f + v\right)$$
$$a - \alpha\left(P'_f + M\right) = b + \beta\left(P'_f + v\right)$$
$$P'_f = \frac{a - b - \alpha M - \beta v}{\alpha + \beta}$$

And therefore:

$$P'_r = \frac{a - b - \alpha M - \beta v}{\alpha + \beta} + M$$

The resulting change in producers' price is:

$$\Delta P_f = P_f - P'_f$$
$$\Delta P_f = \frac{\beta v}{\alpha + \beta}$$

[15] For this study the unit output we use is the metric ton which is equal to 1000 liters.

The resulting change in consumers' price is:

$$\Delta P_r = P_r - P'_r$$
$$\Delta P_r = \frac{\beta v}{\alpha + \beta}$$

And therefore the change in quantity is:

$$\Delta Q = Q' - Q = Q'_f - Q_f = Q'_r - Q_r$$
$$\Delta Q = \beta v - \frac{\beta^2 v}{\alpha + \beta}$$

After some algebra the gains for consumers can be expressed as:

$$G_c(f) = \frac{1}{2}(Q + Q')(P_r - P'_r) = \left(Q' - \frac{1}{2}\Delta Q\right)(\Delta P_r)$$
$$G_c(f) = \left[Q' - \frac{1}{2}\left(\beta v - \frac{\beta^2 v}{\alpha + \beta}\right)\right]\left(\frac{\beta v}{\alpha + \beta}\right)$$
$$G_c(f) = \frac{Q' \beta v}{\alpha + \beta} - \frac{\alpha \beta^2 v^2}{2(\alpha + \beta)^2}$$

Taking in consideration that $P_r - P_f = M = P'_r - P'_f$ where M is the constant per unit margin of the processors, the gains for processors[16] can be expressed as:

$$G_o(f) = Q'(P'_r - P'_f) - Q(P_r - P_f) = Q'M - QM$$
$$G_o(f) = M(\Delta Q) = M\left(\beta v - \frac{\beta^2 v}{\alpha + \beta}\right)$$

[16] Given processors do not process the 100% of the milk produced in El Salvador, we adjusted the gains for the processors by 58% which is the quantity of milk that is actually processed in El Salvador.

The gains for producers can be expressed as:

$$G_p(f) = \frac{1}{2}(Q + Q')[v - (P_f - P'_f)] = \left(Q' - \frac{1}{2}\Delta Q\right)(v - \Delta P_f)$$

$$G_p(f) = \left[Q' - \frac{1}{2}\left(\beta v - \frac{\beta^2 v}{\alpha + \beta}\right)\right]\left(v - \frac{\beta v}{\alpha + \beta}\right)$$

$$G_p(f) = \frac{Q'\alpha v}{\alpha + \beta} - \frac{\alpha^2 \beta v^2}{2(\alpha + \beta)^2}$$

And the aggregate gains for the society can be expressed as:

$$G_s(f) = \left[\frac{1}{2}v(Q + Q')\right] + (Q' - Q)(P'_r - P'_f)$$

$$G_s(f) = \left[Q'v - \frac{1}{2}v\Delta Q\right] + M(\Delta Q) = \left[Q'v - \frac{1}{2}v\left(\beta v - \frac{\beta^2 v}{\alpha + \beta}\right)\right] + M\left(\beta v - \frac{\beta^2 v}{\alpha + \beta}\right)$$

$$G_s(f) = Q'v - \frac{\alpha\beta v^2}{2(\alpha + \beta)} + M\left(\beta v - \frac{\beta^2 v}{\alpha + \beta}\right)$$

For a pivotal shift, the gains for consumers can be expressed the same:

$$G_c(f) = \frac{Q'\beta v}{\alpha + \beta} - \frac{\alpha\beta^2 v^2}{2(\alpha + \beta)^2}$$

The gains for processors remain intact:

$$G_o(f) = M\left(\beta v - \frac{\beta^2 v}{\alpha + \beta}\right)$$

The aggregate gain for the society now is:

$$G_s(f) = \frac{1}{2}vQ + (Q' - Q)(P'_r - P'_f) = \frac{1}{2}v(Q' - \Delta Q) + M(\Delta Q)$$

$$G_s(f) = \frac{Q'v(\alpha + \beta) - \alpha\beta v^2}{2(\alpha + \beta)} + M\left(\beta v - \frac{\beta^2 v}{\alpha + \beta}\right)$$

The gain for producers now is:

$$G_p(f) = G_s(f) - G_c(f) - G_o(f)$$

$$G_p(f) = \left[\frac{Q'v(\alpha+\beta) - \alpha\beta v^2}{2(\alpha+\beta)} - \left(\frac{Q'\beta v}{\alpha+\beta} - \frac{\alpha\beta^2 v^2}{2(\alpha+\beta)^2} \right) \right] - M\left(\beta v - \frac{\beta^2 v}{\alpha+\beta} \right)$$

$$G_p(f) = \frac{Q'v(\alpha^2-\beta^2) - \alpha^2\beta v^2}{2(\alpha+\beta)^2} - M\left(\beta v - \frac{\beta^2 v}{\alpha+\beta} \right)$$

For the quantitative estimation of economic surplus, yearly data from 1993 to 2010 were obtained from The General Directorate of Statistics and Census of the Ministry of Economy, CENTA, DGEA, on milk producer prices, milk retailer prices[17], the consumer price index[18], quantities of milk produced, distribution of milk produced by farm size[19], and distribution of milk consumed by type of consumer, in order to calculate the benefits.

Calculations of the national area planted with the new technologies of sorghum were obtained from experts and then adjusted for forage and silage use only[20]. Then our expert sources estimated that from this area planted for forage and silage with the new sorghum technologies, 20% is planted by small farmers, 50% by medium farmers and 30% by large farmers (R. Clara, personal communication, June 2, 2011). Taking into account average areas of sorghum planted and milk yields (obtained from the interviews), number of farmers with the new technologies and national quantities of milk produced with sorghum technologies were calculated for each size of farm[21]. Then the effect of a

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[17] From 1993 until 2000, the local currency was Colon; the author used the official exchange rate published by The Salvadorian Central Bank (See Appendix C) to convert all the prices to dollars (See Appendix D for real consumer's and producer's prices).
[18] All the prices were adjusted to 2010 prices using the Consumer Price Index (CPI) published by the Salvadorian Ministry of Economy (See Appendix C).
[19] See Appendix E.
[20] For more information see Chapter IV Study Area.
[21] See Appendix I.

reduction in production costs "*v*" in each farm size was calculated for each year (see Appendix J), using the cost reductions of the different farm sizes with and without the technology:

- $v_{(Small\ Farmers)}$ = *(Cost reduction difference of small farms with and without the technology) X (Milk produced by small farmers using sorghum technologies) / (National Total Milk Production).*
- $v_{(Medium\ Farmers)}$ = *(Cost reduction difference of medium farms with and without the technology) X (Milk produced by medium farmers using sorghum technologies) / (National Total Milk Production).*
- $v_{(Large\ Farmers)}$ = *(Cost reduction difference of large farms with and without the technology) X (Milk produced by large farmers using sorghum technologies) / (National Total Milk Production).*

Afterwards an aggregate "*v*" was calculated by adding up the "*v*"s of each farm size group:

- $v_{(Aggregated)} = v_{(Small\ Farmers)} + v_{(Medium\ Farmers)} + v_{(Large\ Farmers)}$

In 2007, 58% of the milk produced by farmers went to processors, 6% to self-consumption and 36% to final consumers (Salvadorian Department of Economy, 2007, p. 1). We adjusted the consumers' prices to reflect this division of final markets. Only for the processed milk were the official consumer price data used[22]. For own production the producer price is the relevant price. For direct sale without processing we used the producers' price and added another 10% for transportation costs:

[22] Only for the calculation of the gains for the processors we used the official consumer price and not the weighted consumer price.

- *Weighted Consumer Price = (Retail Price X 0.58) + (Producer Price X 0.06) + (1.1 X Producer Price X 0.36).*

Once we have determined all these parameters, the changes in economic surplus for each year can be calculated using the previous formulas for producer, consumer and social gains. We estimated this for both, a parallel shift and a pivotal shift of the supply curve. In results we will first show empirically the supply curve estimated in the field. Also note that for the calculation of total producer gains we use the parameter $v_{(Aggregated)}$ and for the calculation of small, medium and large farmers gain we use the parameters $v_{(Small\ Farmers)}$, $v_{(Medium\ Farmers)}$ and $v_{(Large\ Farmers)}$ correspondingly.

For the calculation of the present value of the benefits we did not have to discount the benefits of each year since our data on prices were adjusted to 2010 prices using the CPI and our costs were already given in 2010 prices. The internal rates of return to agricultural research (IRR) were also calculated. The IRRs can be compared with returns on alternative public investments.

CHAPTER 4. STUDY AREA

4.1 El Salvador: Economic Growth & Agriculture

El Salvador, literally meaning Republic of The Savior, is the smallest and the most densely populated country in Central America. As of 2009, El Salvador had a population of approximately 6.3 million people. The “Colón” was the official currency of El Salvador from 1892 to 2001, when it adopted the U.S. Dollar. El Salvador's Human Development Index (HDI) is 0.674, placing El Salvador below the regional average of Latin America and the Caribbean of 0.731. Presently the country is undergoing rapid industrialization (International Human Development Indicators, 2011).

Due to the country’s limited land area, opportunities for expansion or relocation of agricultural activities are limited. Agricultural development and population growth are leading to physical concentration and pressures on resources specially water and land. As competition for land intensifies, agricultural activities such as grain crops (maize, beans, sorghum) and livestock grazing are being marginalized and/or replaced, either by non-agricultural activities or by agricultural activities with higher-value outputs, which require higher capital inputs and less land, such as intensive livestock raising or horticulture.

The agricultural sector has been for many years the most important economic sector of the economy. Following the armed conflict in the 80's and the successive land reforms, agriculture began to lose importance in favor of industry and services. In 2010, agriculture represented 13% of the GDP and 19% of employment in El Salvador. Although this percentage has been declining steadily since 1990, the links of agriculture with other sectors of the economy are extensive. More specifically, the primary agricultural sector is closely linked with agribusiness and commercial agricultural production chains in areas such as coffee, bananas, sugar, oils, flours, concentrates, fruit, meat, dairy, fisheries and aquaculture. With these linkages, agriculture's share in the GDP is much more significant than the value of production alone (Central American Agricultural Council, 2007).

Livestock raising in El Salvador, is considered strategic for its contribution to the economy and lifestyle of the country's vast rural areas; it has the third place in the contribution to the Agricultural GDP. The industry of meat and dairy earns approximately $ 275 million and generates more than 130,000 rural jobs (Garza, 2008). The dairy industry in El Salvador includes dairy farming with dairy processing resulting in pasteurized milk, which is the most important dairy product for consumers in El Salvador (Salvadorian Department of Economy, 2009, p. 2).

4.2 Dairy Producers in El Salvador

Production systems for dairy farming in El Salvador are differentiated by their degree of technological adoption, herd size, and the farm size. We use the size of the herd in milk production to classify the production systems in El Salvador.

4.2.1 Small Farmers

This group is generally known as traditional producers. In this category are included producers owning less than 20 heads of cattle in milk production. Here there is little or no adoption of technology, including keeping the calf with the milking cow most of the day. The races are normally Brahman crosses with native cattle. Most of the milk produced by this group is used for home consumption. Surpluses are sold locally to help with family finances. These farmers represent 15% of national milk production (Technoserve, 2009, p.14).

4.2.2 Medium Farmers

These farmers are called semi-technified. This group has from 20 to 50 cows in milk production. The reproduction system generally involves natural mating with Holstein and Brown Swiss bulls. This group employs accounting record systems, has stables and feeders with roofs for the cattle, and applies some technology in the milking including disinfecting udders with iodine solution and washing utensils and milking equipment with detergents. Their milk is higher quality than that of the small producers. These farmers represent 45% of national milk production (Technoserve, 2009, p.14).

4.2.3 Large Farmers

This group applies more sophisticated management system and has more than 50 cows in milk production. The practice of artificial insemination by this group has improved races. These farmers employ more feed supplementation. They utilize mechanized milking systems and perform hygienic milking practices such as washing and drying udders, udder dipping and prevention of mastitis. To control heat stress, sprinklers, fans, shades, or treatment rooms are common. They milk 2 or 3 times per day, placing the milk directly into cooling tanks of stainless steel. This maintains a better quality for the product reducing contamination. They also have access to bank loans and receive substantial technical assistance. These farmers often have annual contracts with processors for constant annual milk prices. They represent 40% of national milk production (Technoserve, 2009, p.14).

4.3 Institutional Development and Extension in the Dairy Industry

Following the agrarian reforms of the 1980 and the termination of the civil war in 1989, the milk producers association of El Salvador (PROLECHE) was created in 1993. The objective was the rehabilitation of the dairy sector with the assistance of Israeli experts and funds made available by USAID.

The project of the Israeli Mission included training local instructors, the introduction of modern technologies, and the extensive rehabilitation of a number of ranches. Training was carried out on-site by an Israeli expert in cooperation with 8 local instructors, who received professional training, and participated in courses conducted in Israel. The project conducted field days in different dairy farms as well as courses delivered at the National School for Agriculture (The Israel Project, 2008). Salaries and transportation for the local instructors were provided by the Salvadorian Ministry of Agriculture.

This dairy project was mainly concerned with training farmers at all stages of production including conservation and marketing of milk. From 1993 to 2004 there was a transformation of dairy production[23]. Over the 15 years 1995-2010 dairy productivity was approximately doubled to 20 bottles[24] (15 liters) of milk per cow per day on PROLECHE farms, compared with previous national averages of 11 bottles (8.25 liters) (Morales, personal communication, June 30, 2011).

4.4 Varietal Development of the Insensitive Cultivars of Sorghum

After white corn, sorghum is the second grain produced in El Salvador. By 2010 its production reached 163 thousand metric tons on 93 thousand hectares, producing an average yield of 1.74 mT/ha (MAG, 2007). Due to the interest in forage, caused by the increasing dairy production in the country, the Basic Grains Program of CENTA has devoted significant research to the testing for adaptation and the crossing[25] of photo-insensitive[26] sorghum.

One objective of the collaborative research between CENTA and INTSORMIL has been to offer farmers improved sorghum varieties and hybrids that have better quality

[23] In addition, the Japanese International Cooperation Agency (JICA) ran various artificial insemination and embryo transplant programs to upgrade Salvadoran cattle genetics (USDA, 2001, p.4).
[24] The Salvadorian unit of milk production is the bottle which is equivalent to 0.75 liter.
[25] The cultivar and hybrid breeding have used traditional pedigree approaches, with populations generated from American universities (principally Texas A&M University) and the ICRISAT sorghum breeding programs. The best performing materials from these population trials were given to CENTA for evaluation and testing in El Salvador and other countries of Central America. When successful, these materials resulted in the release of improved, locally-adapted cultivars for grain and/or forage production. Varieties S-2 and RCV and Hybrid SS-44 were the result of crossing trials while variety S-3 was the result of adaptation trials.
[26] The sensitive sorghums are planted beneath the maize in the first season (See Appendix F for more information about sorghum planting seasons in El Salvador) and wait for the light and rapid development until the maize is broken in the period between the two seasons ("canicula"). The sensitivity to light then insures that they will not compete with the maize but just wait their turn at the light. Insensitive sorghums are planted in monoculture in the second season. Photo-insensitive varieties are those whose flowering is not affected by the amount of daylight hours and flower regardless of the time they are planted. Photo-sensitive varieties (landraces) are those which flower only when days are short (November-December). Photo-insensitive sorghums need a greater amount of soil moisture for pollination and grain filling, compared with the photo-sensitive cultivars (R. Clara, personal communication, May 27, 2011).

and more digestible crop forage to feed their livestock. This has resulted in the release of S2, S3, RCV and SS-44 that are now commonly grown throughout El Salvador (R. Clara, personal communication, May 30, 2010). The first three cultivars are used as either dual purpose[27] or silage while the hybrid SS-44 is grown for its multiple cuts for grazing, hay and silage (for more information on agronomic and nutritional characteristics see Appendix G).

Estimates of the total area planted over time with CENTA S-2, CENTA RCV, CENTA S-3 and CENTA SS-44 were calculated with the help of experts, and them compared with the data on certified seed production from the CENTA archives of seed production (See Appendix H) of the three main sorghum seed companies of El Salvador, PROSELA, UPREX and VILLAVAR[28] (See Figure 4.1).

[27] Dual purpose means that the grain can be sold and the rest of the plant used for forage. This activity is performed only by small farmers who do not own any cattle. This grain is sold for poultry or concentrates either on the farm or sold to industry. After harvesting the grain, these farmers graze their animals and/or allow neighbor's cattle to graze in their property what was left of the sorghum plant. They may charge a fee for this activity, depending on the area they allow to be grazed or the herd size. Medium and large livestock farmers do not sell the grain since it is used to feed the cattle along with the forage.

[28] These three sorghum seed companies along with CENTA are the only ones producing certified seed in El Salvador. Every year these companies have to report their seed production in order to be certified by CENTA. There are also inspections by CENTA technicians of the production conditions of these seeds.

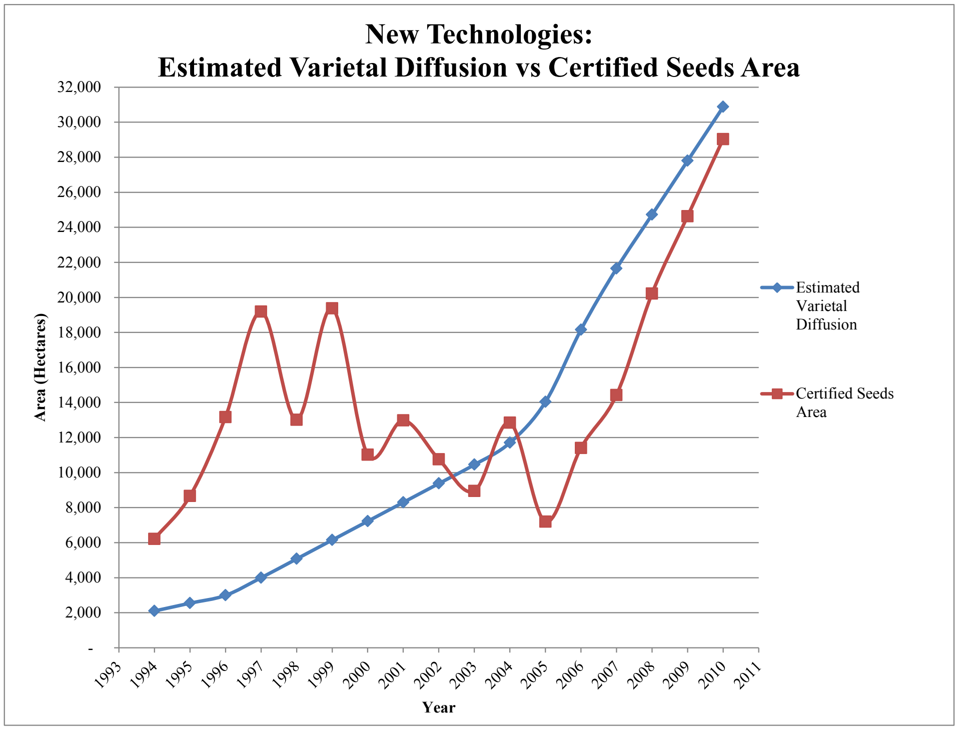

Figure 4.1 Comparison between Estimated Varietal Diffusion and Area Planted with Certified Seed.
Source: Villacís, 2011.

One explanation for the initial higher area with certified seed than our estimates of diffusion over the period 1993 to 2003 is that the certified seed data reflect seed production by the seed companies rather than sales. The government initially encouraged these companies to produce seed and then did not buy it.

Normally diffusion occurs with a gradual logistic curve as more and more producers see other producers using the cultivar. This is more consistent with our curve of the introduction than the data on certified seed production. After 2005 the gap between certified seed and our diffusion estimate undoubtedly results from farmer or other non-certified production of seed.

Not all of the area planted with the new sorghum technologies is used for dairy cattle feeding[29]. There is also substantial area of grain production for the poultry industry, especially of CENTA-RCV. Hence, area estimates for the use of CENTA S-2, CENTA-RCV, CENTA S-3 and CENTA SS-44 for the production of forage and silage were adjusted (See Appendix H) by experts in the field. These adjustments were respectively 94%, 27%, 73% and 100% of the area utilized for dairy production (See Figure 4.2).

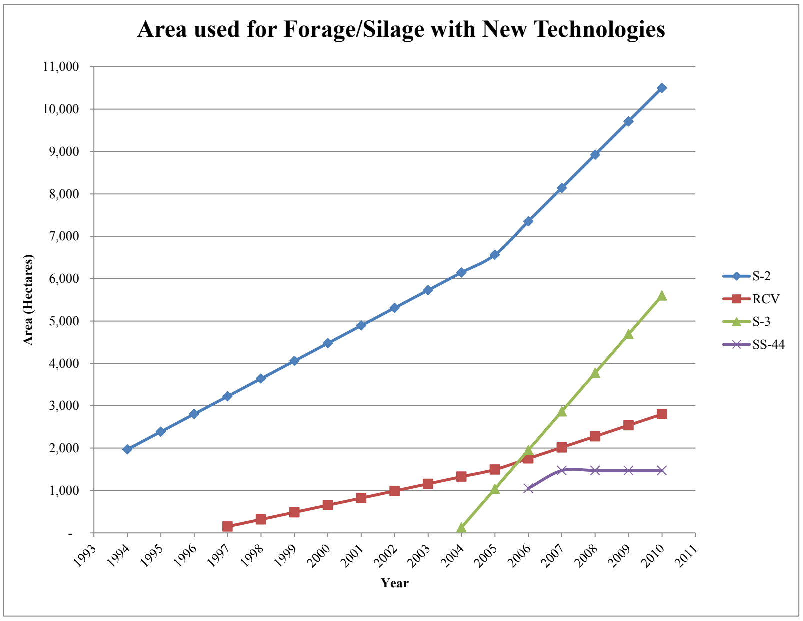

Figure 4.2 Area Used for the Production of Forage and Silage of the Four Sorghum Cultivars Under Study.
Source: Villacís, 2011.

S-2 is the most widespread variety for production of forage and silage due to its earlier introduction and because its seed is easier to find on the market in comparison with the other varieties. The hybrid SS-44 is in the early stage of introduction and is only produced by CENTA. This cultivar is a major change as it will allow the increase of sorghum cuts from two to four.

[29] Beef cattle production in El Salvador is very small and most beef consumed comes from Nicaragua.

4.5 Silage Introduction and Diffusion

The introduction of silage dates from the early 80's; however, during the civil war there was little diffusion. During the 90's with the support of the Salvadorian government and the assistance of the Israeli government, the use of silage began to be widely disseminated among Salvadorian dairy farmers. By 2010 approximately 60% of the dairy farms in El Salvador used silage while the 40% remaining use some combination of forage and pastures[30] (Araujo, personal communication, June 10, 2011).

4.6 Characteristics by Farm Size (Small, Medium & Large)

The surveys indicate substantial differences in daily productivity per cow with productivity of large producers almost three times that of small producers (Table 4.1).

Table 4.1 Characteristic of Dairy Sorghum Farms in El Salvador.

Characteristic	Farm Size		
	Small	Medium	Large
Hectares under sorghum	2.39	8.30	15.40
Herd Size Average	10.69	32.83	69.88
Milk Liter/Day/Cow	6.27	11.39	15.43
Milk mT/Year/Farm	24.14	134.60	388.28

Source: Villacis, 2011, Survey Data.

Results also show that the productivity of the non-sorghum[31] producers is slightly higher than those of the sorghum producers (See Table 4.2). The explanation for this is the moderately higher nutritional value and greater palatability of maize[32] resulting in

[30] It is considered that the majority of dairy farms in El Salvador use concentrate (Araujo, personal communication, June 10, 2011). This concentrate would be either their own mix or a prepared concentrate from one of the Salvadorian firms.

[31] Non-sorghum farmers interviewed were maize users, which along with sorghum is one of the most important crops used for forage and silage in El Salvador.

[32] Note that maize has only one cut.

more consumption and increased milk production (Landaverde, personal communication, August 25, 2011).

Table 4.2 Characteristic of Dairy Non-Sorghum Farms in El Salvador.

Characteristic	Farm Size		
	Small	Medium	Large
Herd Size Average	12.79	31.33	76.88
Milk Liter/Day/Cow	6.65	12.52	16.93
Milk mT/Year/Farm	30.61	141.14	468.69

Source: Villacis, 2011, Survey Data.

4.7 Cost Savings by Farm Size (Small, Medium, Large)

The advantage of sorghum is that multiple cuts[33] reduce the costs of feed per unit of milk. These reductions are small indicating that the entire dairy sector is improving with and without sorghum but there are still small cost advantages for the farms which use sorghum as a feed (Table 4.3).

Table 4.3 Feed Costs of Dairy Farms in El Salvador (US$).

Characteristic	Farm Size		
	Small	Medium	Large
Cost / bottle of milk in Dairy Sorghum Farms	0.1879	0.1964	0.2159
Cost / mT of milk in Dairy Sorghum Farms	250.57	261.81	287.80
Cost / bottle of milk in Dairy Non-Sorghum Farms	0.1909	0.2007	0.2202
Cost / mT of milk in Dairy Non-Sorghum Farms	254.52	267.61	293.58
Change in cost per bottle of milk	0.0030	0.0044	0.0043
Change in cost per mT of milk	3.95	5.80	5.78

Source: Villacis, 2011, Survey Data.

[33] Sorghum producers can get up to 4 cuts for SS-44. The dual purpose cultivars generally are limited to two cuts by the available rainfall. Irrigation changes this for these varieties.

4.8 Costs of Research and Extension

Figure 4.3 summarizes the estimated research and extension service costs incurred in the improvement and diffusion of the sorghum varieties under study (See also Appendix K). Data on research costs in terms of total resource investment (equipment and personnel) and operating expenditures are included.

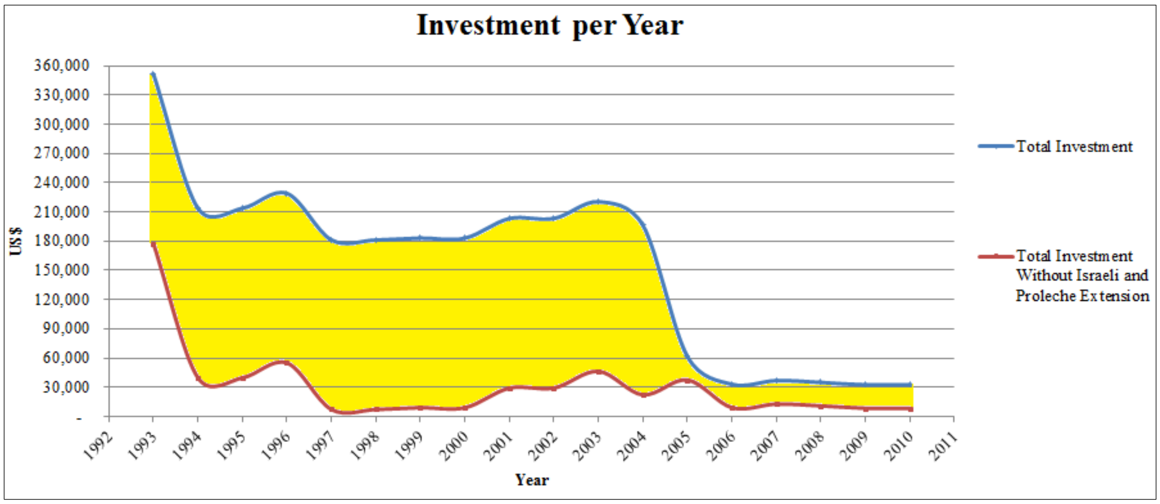

Figure 4.3 Annual Research Investment with and without Extension Costs of PROLECHE and the Israeli Government.
Source: Villacís, 2011.

The importance of the USAID investment in extension through supporting PROLECHE and of the Israeli investments in training and developing the technologies is clear from the above figure. These are treated as public costs to the government of El Salvador as they were an important component of extension that the government would have had to pay in the absence of the foreign assistance. The initial high cost in year 1993 results from the cumulative cost incurred from 1976 until 1992 for variety S2. In these years this variety was developed and introduced in the country but the civil war held up the diffusion process (R. Clara, personal communication, August 16, 2011).

CHAPTER 5. RESULTS

This chapter looks at the changes in producer's, processor's and consumer's surplus of the economic surplus method applied to the diffusion of the new photo-insensitive sorghum varieties for dairy production. The chapter is divided into two sections. The first section discusses the choice of the type of supply shift due to the technological change while the second section presents the benefits to consumers, processors, producers and the society.

5.1 The Choice of the Type of Supply Shift

The choice in the analysis of the type of supply shift due to the technological change is critically important. As mentioned before, total benefits from a parallel shift are almost twice the size of total benefits from a pivotal shift (See figure 5.1).

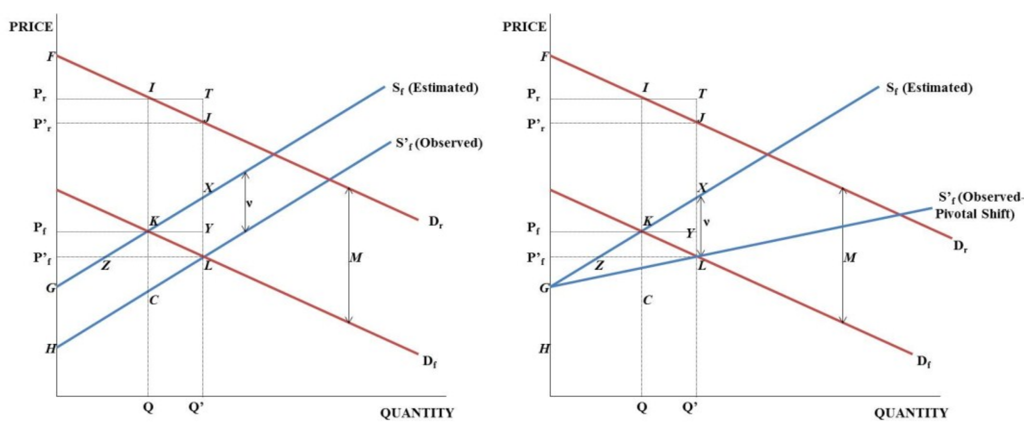

Figure 5.1 A Parallel Shift vs. a Pivotal Shift of the Supply Curve.
Source: Villacís, 2011.

Economic theory is not explanatory about the type of supply shift (Lindner and Jarrett, 1978). Hence we look at the empirical data on infra-marginal and marginal producers comparing the production costs between farmers with and without the new technologies (See figure 5.2 and 5.3).

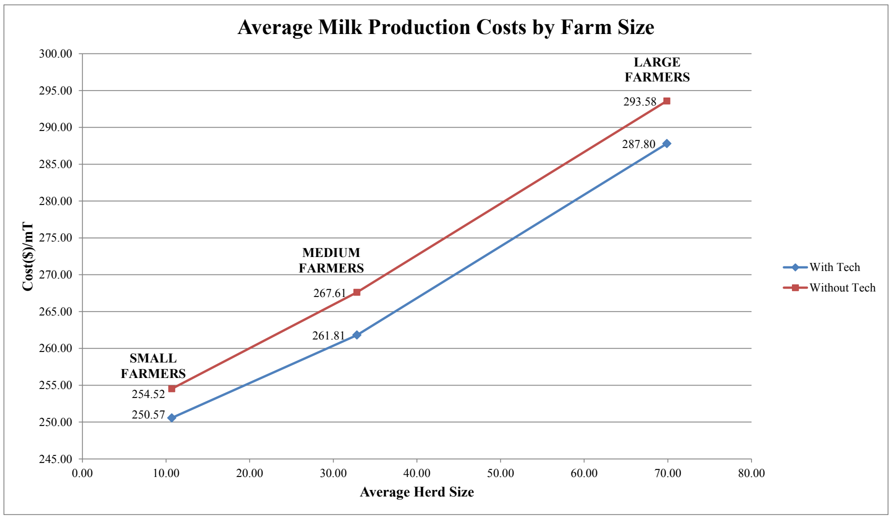

Figure 5.2 Average Milk Production Costs vs. Average Herd Size. Source: Villacís, 2011.

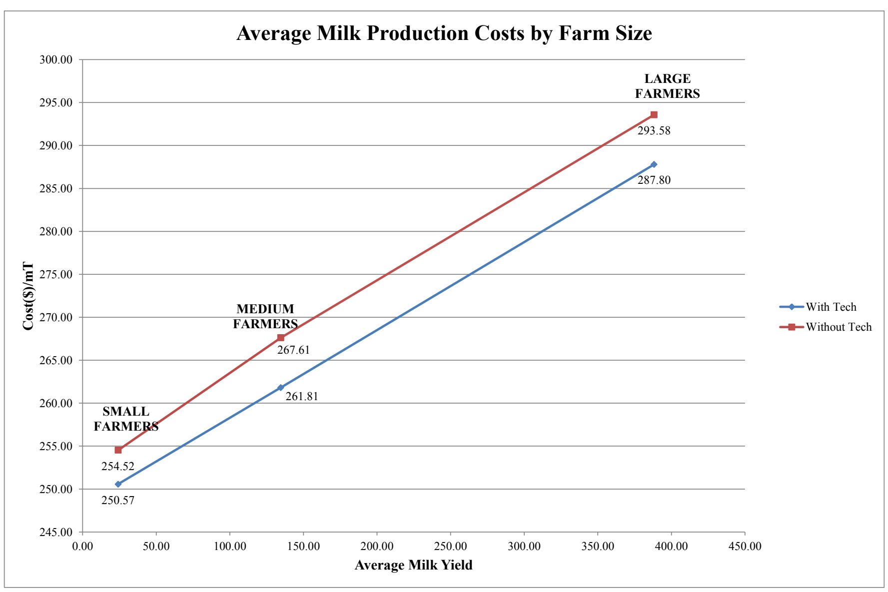

Figure 5.3 Average Milk Production Costs vs. Average Milk Yield. Source: Villacís, 2011.

As we move from small to medium farmers there is a proportional supply shift while from medium to large farmers the shift is almost parallel. This technology introduction did not produce a pivotal nor a parallel shift[34]. It appears that the use of a parallel shift is a good approximation[35].

5.2 Benefits to Consumers, Processors, Producers and the Society.

Results shows that assuming a parallel shift of the supply function caused by the introduction of new technology, as a group within producers, medium size farmers are the principal beneficiaries from these cost savings technologies and then the large farmers[36]. Making the calculations for benefits we have (See Figure 5.4 and Appendix L):

[34] Lindner and Jarrett (1978) demonstrate the influence of the nature of the shift of the supply curve on the total level of annual social benefits and present a general formula for measuring those benefits. Additionally they offer insights on the factors which might lead to particular types of supply shift.

[35] A parallel shift implies the change in average cost equals the change in marginal cost at every point along the curve.

[36] Although cost savings per metric ton of milk are almost the same for medium and large farmers (See Table 4.3), medium farmers as a group benefit more due to the larger number of medium farmers than large farmers in El Salvador.

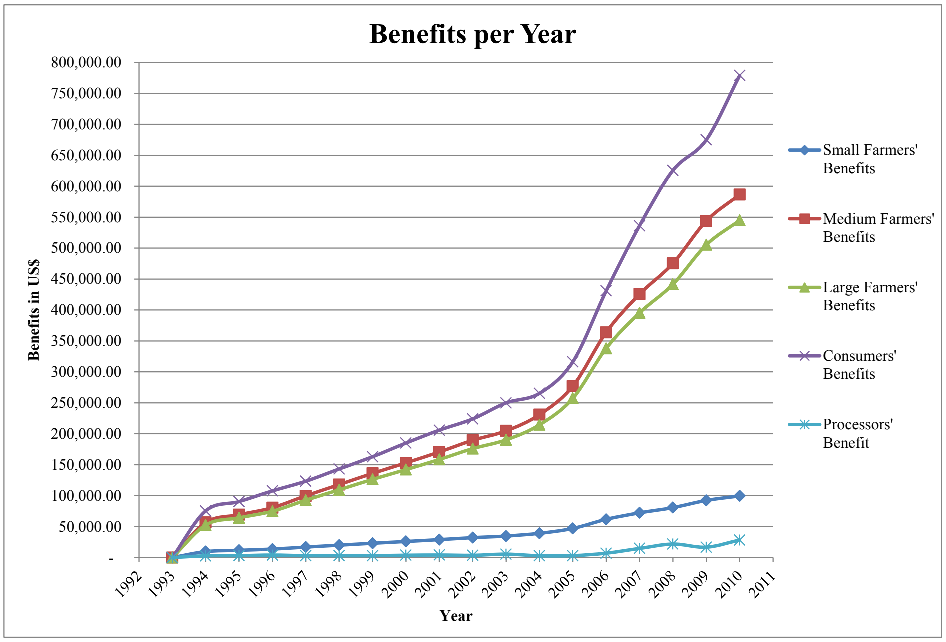

Figure 5.4 Private Benefits per Year for Consumers and Producers (When a Parallel Shift is Assumed).
Source: Villacís, 2011.

Large producers received almost $3.9 million and medium sized producers earned another 4.2 million dollars. As a group, producers benefited from the lower costs of production hence increased profits. Their benefits were 8.8 million dollars when aggregated over the national production. Processors' benefits were low, reaching one hundred and thirty thousand dollars. Consumers' benefits from the lower prices of milk were over 5 million dollars during the period, 1993-2010.

Processors benefited from lower producer's prices but due to the use of constant per unit margins, they face lower consumer prices at the same time. This leaves benefits depending principally upon the increased quantity of milk produced with the new technologies.

The accumulated per year gross benefits (private net benefits to consumers and producers) to society from this research reached over 14 million dollars in 2010 (See Figure 5.5 and Appendix L).

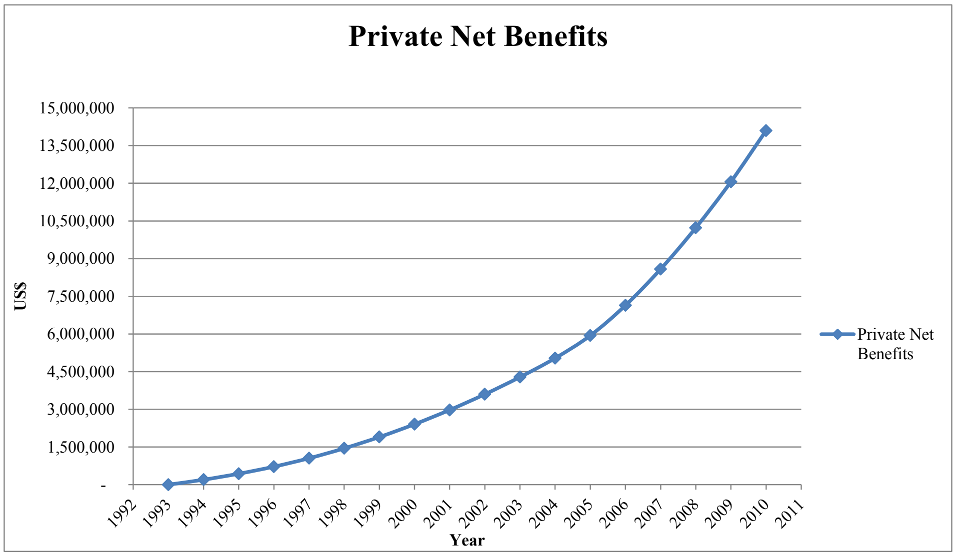

Figure 5.5 Cumulative Private Benefits to the Society from the New Technologies (When a Parallel Shift is Assumed).
Source: Villacís, 2011.

Note that we could have projected these benefits out another ten years because the pace of technology introduction was accelerating with the introduction of SS-44. So this is a conservative total estimate of benefits. The net benefits to society after deducting the costs to the public sector are illustrated in Figure 5.6 (See also Appendix L).

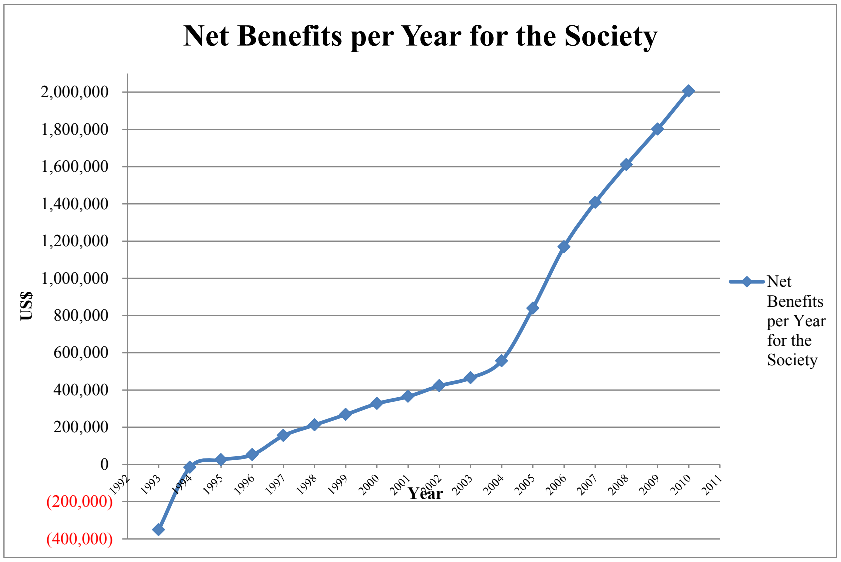

Figure 5.6 Net Public Benefits to the Country from the Investments in the Insensitive Sorghums (When a Parallel Shift is Assumed).
Source: Villacís, 2011.

Cost savings for producers were less than 1/2 cent per bottle (See Table 4.3). But total consumer benefits were over 5 million dollars when aggregated over all the bottles sold (See Table 5.1).It is important for policy makers to see the total benefits to society even with these very small benefits per bottle which would tend not to be noticed.

Table 5.1 Net Benefits for Consumers, Producers and Society (Parallel Shift).

	Benefit (US$)
Consumer's Surplus	$ 5,195,411
Processor's Surplus	$ 130,280
Producer's Surplus	
Small Farmers	$ 709,330
Medium Farmers	$ 4,180,398
Large Farmers	$ 3,883,500
Total	$ 8,772,432
Gross Benefit to Society	$ 14,098,124
Total Research Cost	$ 2,790,917
Net Benefits to Society	$ 11,307,206
IRR	38%

Source: Villacis, 2011

The internal rate of return of 38% is a good return on the public investment. Average returns on investments in El Salvador have been estimated at 18% in real terms net of inflation (Trigueros & Oliva, 2008). So this was a better than average investment of public resources.

A pivotal shift is used as a lower boundary estimate. It principally reduces the benefits to farmers and total returns while consumers' gains and processors' gains remain intact. Note that consumers' gains were larger than the total producers' gains when a pivotal shift was assumed (See Table 5.2 and Appendix M).

Table 5.2 Net Benefits for Consumers, Producers and Society (Pivotal Shift)

	Benefit (US$)
Consumer's Surplus	$ 5,195,411
Processor's Surplus	$ 130,280
Producer's Surplus	
Small Farmers	$ 144,610
Medium Farmers	$ 852,039
Large Farmers	$ 791,543
Total	$ 1,787,395
Gross Benefit to Society	$ 7,113,087
Total Research Cost	$ 2,790,917
Net Benefits to Society	$ 4,322,169
IRR	17%

Source: Villacis, 2011

The internal rate of return of 17% is an average return on the public investment. The pivotal shift substantially reduces the benefits to producers and the rate of return to research. But we are convinced that the returns here and the nature of the supply shift are much closer to the parallel than to the pivotal shift.

5.3 Summary

If we compare benefits to consumers with the parallel shift, the benefits of each of the other groups individually (processors, small, medium and large farmers), consumers are the principal beneficiaries of these new sorghums technologies. When benefits to small, medium and large farmers are gathered together into one group, these benefits are greater than the benefits for consumers. In the next chapter we evaluate the sensitivity of those distribution results to the price elasticities of demand and supply

CHAPTER 6. FURTHER DISCUSSION

This chapter looks at further issues affecting the distribution of benefits between producers and consumers as well as issues affecting competition in the milk industry of El Salvador. The chapter is divided into two sections. The first section presents a sensitivity analysis of the distribution results to the price elasticities of demand and supply while the second section discuss processors' margins and market power of the processors.

6.1 Sensitivity Analysis: Elasticities and the Distribution of Benefits

The economic surplus approach required the use of supply and demand elasticity estimates. We show that elasticity assumptions play an important role in the distribution of benefits among consumers and producers. Varying elasticities of supply and demand minimally affects total returns[37] but has substantial effects on the distribution of benefits between producers, consumers and processors.

Because elasticity parameters were not available from previous studies in El Salvador, initial parameter values were taken from other studies and sensitivity analysis is done in this section.

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[37] Changes in Total Private Net Benefits did not exceed more than $16,235 for both cases (a parallel shift and a pivotal shift).

Since milk has few substitutes (e.g. soy milk) and is increasing regarded as a basic or necessary food commodity, we expect a very low price elasticity of demand. Milk is now similar in El Salvador to rice and beans. People in El Salvador consider milk a basic component for daily food diets and adjust their purchases to attempt to maintain milk consumption levels even when higher prices occur for this commodity so they can still consume it. Hence the price elasticity of demand of -0.2 was considered appropriate.

Processed dairy products become more important with increasing incomes and living standards, so we could expect higher price elasticities of demand over time. Over time this price elasticity would increase (see Figure 6.1) as other uses of milk become more wide spread. Other milk sub-products including ice cream, cheese and butter are more price elastic as they compete with a larger number of other substitutes and are not considered as necessities in the diet.

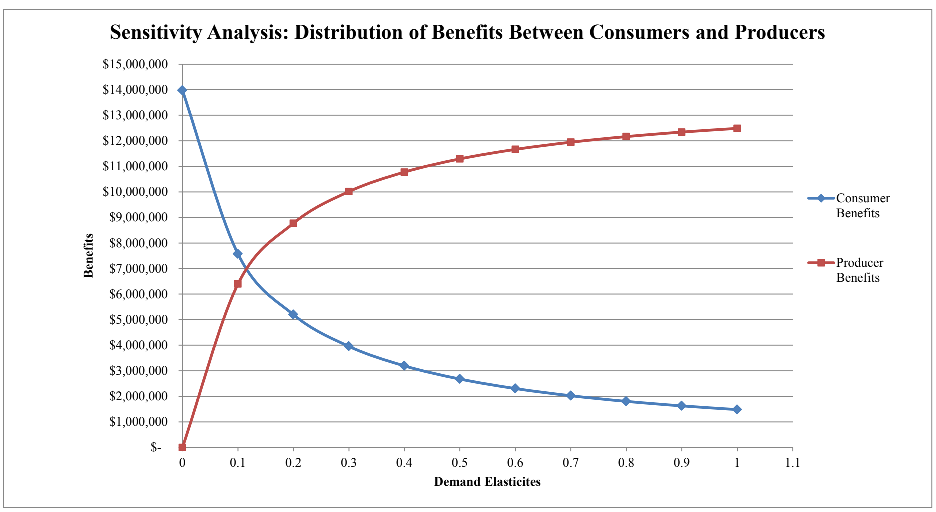

Figure 6.1 Distribution of Benefits between Consumers and Producers Holding Supply Elasticity Fixed at 0.1 and Relaxing Demand Elasticities (Parallel Shift).
Source: Villacís, 2011.

When demand elasticities increase in absolute terms, returns to consumers decrease. This results from consumption patterns changes toward other substitutes. This change is expected as the number of milk products and processing firms increase.

The supply price elasticity of milk is determined by the ease of shifting new resources or technologies into this sector. Currently in El Salvador there are large capital requirements for large farmers, the principal innovators, to enter dairy production, including investments in improved livestock races, mechanized milking systems, cooling tanks of stainless steel and other infrastructure. Since these are substantial investments we expect a slow price response over time. Additionally due to the country's limited size there are high pressures on resources especially water and land, which reduce the option for expansion of extensive activities of pasture. Over time with area expansion by opening up low quality land resources, or with the introduction of new technologies, the supply elasticities would increase (see Figure 6.2) but we use here the very inelastic supply response of 0.1.

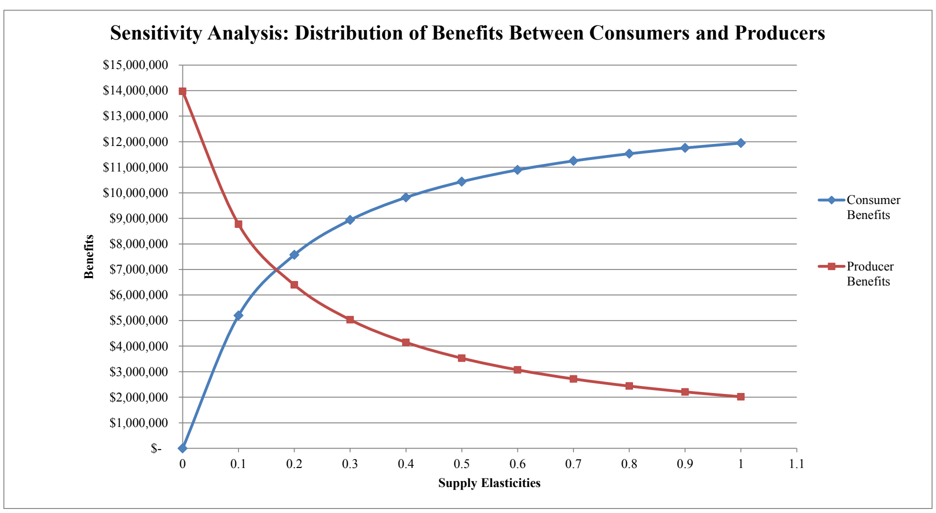

Figure 6.2 Distribution of Benefits between Consumers and Producers Holding Demand Elasticity Fixed at 0.2 and Relaxing Supply Elasticities (Parallel Shift).
Source: Villacís, 2011.

In figure 6.2 we see that as supply elasticities increase, returns to producers decrease[38]. The expansion of the utilization of idle land, being promoted by producers presently, could increase the supply elasticity. Other investments in infrastructure and new technologies for dairy production could also make supply more elastic. We could expect both price elasticities of demand and supply to increase with the former probably increasing at a faster rate. Hence, producers' surplus would be expected to grow over time relative to consumers' surplus

6.2 Competition in the Milk Industry

Imperfect competition can result in effects on the size and distribution of benefits. However, there appears to be substantial competition in the dairy industry. In El Salvador there are 6 milk processing plants with volumes ranging from 10 to 60 metric tons per day[39]. These processors include Petacones, Lactosa, El Jobo, La Salud, Foremost and San Julián. There is substantial competition between these firms. Also there is no protection from imports except for transportation costs.

Companies from other countries have not achieved a strong penetration in the Salvadorian market. The only minor exception is the case of UHT[40] milk, with the Costa Rican company Dos Pinos producing this product. Market knowledge, consumer

---

[38] See Appendix N for a complete sensitivity analysis when a parallel shift of the supply curve is used. For the case of a pivotal shift of the supply curve, consumers always benefit while producers do not always benefit in the aggregate. Results show that only when price elasticity of demand is greater than price elasticity of supply, do producers benefit from research. See Appendix N for a complete sensitivity analysis when a pivotal shift of the supply curve is used. Note that initial adopters will still benefit. Comparative statics shows the final adjustment after the new equilibrium prices are attained

[39] Dairy processors use primarily domestic milk as raw material. During times of shortage of milk they have supplemented their needs with imported milk powder. Note that in El Salvador the rehydration of imported milk powder to produce fluid milk is prohibited.

[40] Ultra-high temperature processing.

preferences and the presence of strong local brands have been the primary reasons why other Central American industries have failed to penetrate significantly in the country (Barahona[41], personal communication, June 10, 2011).

We can also study market power by evaluating margins over time. In this study we assumed constant per unit margins of the milk processors so we need to examine the actual performance of these margins over time[42] (see figure 6.3).

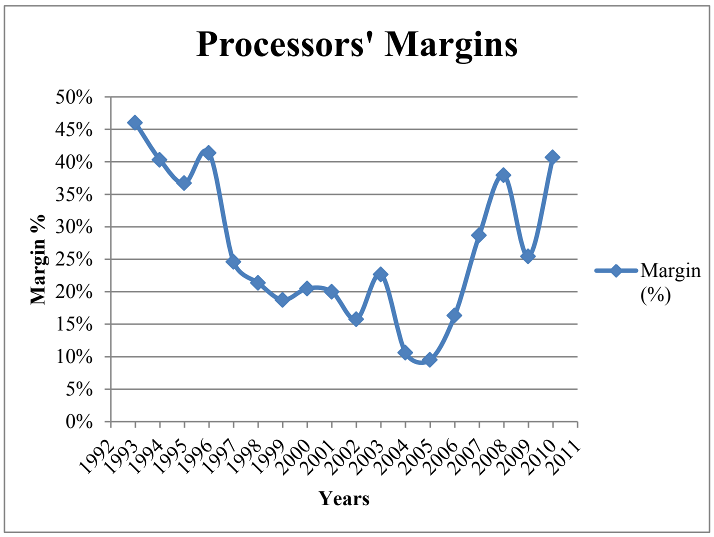

Figure 6.3 Processors Margins in the Dairy Industry of El Salvador.
Source: Villacís, 2011.

Rather than increase, margins decrease from 1993 to 2005, apparently indicating improvements in transportation and communication after the end of the civil war as El Salvador rebuilt and investments in infrastructure increased. So it became cheaper to move milk and this also encouraged increased milk production.

Then from 2006 to 2010 these margins increase so it may be important in the future to study the market power of the processors. Nevertheless our judgment of the

[41] Guillermo Barahona is the actual CEO of the milk processing plant La Salud.
[42] See Appendix O.

principal factors here is that over time as more uses are made of milk with more ice cream, cheese and butter, the price elasticity of demand increases as there will be more substitutes and more firms. The increased margins beginning in 2006 apparently reflect changes in consumption towards different qualitative uses of milk (shifts to ice cream, butter, cheese, different grades of milk) rather than increasing market power of the processors for "milk".

If retail demand (D_r) becomes more elastic over time relative to the processors' demand (D_f), this could results in increasing margins as shown below in figure 6.4.

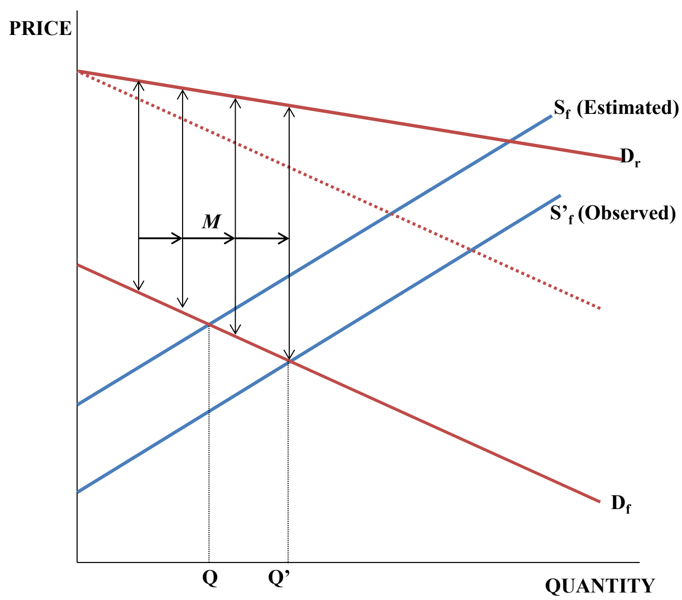

Figure 6.4 Effect on Margins of a More Elastic Retail Demand (D_r) Relative to the Processors' Demand (D_f).
Source: Villacís, 2011.

Further research could estimate the retail and processor demand elasticities. However, the market power concentration for increasing margins is not expected to be a problem due to the large number of products and processors involved in total milk production.

CHAPTER 7. CONCLUSIONS AND POLICY IMPLICATIONS

This study finds evidence that investment in sorghum agricultural research in El Salvador has generated large returns per dollar spent and substantially benefited producers and consumers. This development has helped keep milk prices down and probably increased foreign exchange (cheese exports).

Compared with maize (which along with sorghum is one of the most important crops used for forage and silage in El Salvador), sorghum feed represents advantages in production costs of milk in each farm size. The cost savings per bottle are very small individually therefore people and policy makers tend not to notice them. When aggregated over the whole national milk production and consequently to the society, these are large changes. Hence this study is very useful to document that small savings in production costs can produce large gains to consumers, that otherwise would not be noticed, especially when compared to something that is very visible such as highways, stadium or parks.

There were good returns on this research investment at 37% and even at the extreme and most conservative assumption of a pivotal supply shift, returns were still an average investment of 17%. Our evidence showed that the use of parallel shift of the supply function is closer to reality than the use of a pivotal shift.

The returns to producers are higher than those for consumers but the returns for consumers are greater than those for large producers. From both, efficiency and an equity perspective, these public sector expenditures were very beneficial to El Salvador.

In the effort to design technology for small producers the public sector often forgets that one principal beneficiary of agricultural technologies for domestic consumption is the consumer. Hence for rapid growth sectors with changes in consumers habits such as the demands for milk, milk products, broilers, fruits and vegetables, there probably needs to be a focus on large (and medium) producers, who can rapidly adapt and expand production with new technologies so that relative prices do not increase as fast and benefits to consumers are maximized.

We understate benefits here by not including the value of the grains for the dual purpose case when the grain is sold and the rest used for forage. This would be especially the case for earlier years in the '90s and for the small farmers. Note that including these grain sales would give larger benefits to small farmers.

Also this same technology is expected to continue generating benefits for another decade and the projected future benefits could also have been included in this analysis. SS-44 will double the number of cuts of sorghum now so benefits to dairy should be increasing faster in the next decade. Moreover, there is a new generation of brown midrib sorghum with even higher nutritional advantages being introduced now. Note that historical returns do not necessarily predict future returns, but we expect continued rapid demand for milk and productivity growth in the sector.

In the absence of new sorghum technology introduction, the main option available for forage and silage feed for livestock farmers is the use of maize, which represents higher production costs and does not have the advantage of the multi-cuts presented in sorghum. The absence of sorghum technologies would have increased milk prices, reducing consumer and producer benefits.

The success of the introduction of these technologies by CENTA was substantially aided by the extension role played by PROLECHE. Also the Israeli aid mission played a large role in the development of the sector and recommended the use of sorghum for forage and silage. Presently PROLECHE is accelerating the diffusion of the hybrid SS-44 of CENTA, by purchasing all of the seed production of this hybrid and selling it to its members. Other countries should note the association of this large investment in extension for a complicated production system then resulting in substantial productivity increases and high economic returns.

In the agricultural development program of the government, sorghum is not included. Only the primary food commodities of rice, beans and corn are included as the basic grains for this program[43]. Sorghum is not a primary food except in bad rainfall years as a substitute for maize, but sorghum has become very important in reducing costs and increasing productivity of milk producers. Milk is also a principal food for low income consumers in El Salvador.

There are apparently high returns for agricultural scientists to continue developing improved sorghum varieties for milk production. This would include the BMR (brown midrib) varieties developed by Rene Clara at CENTA in El Salvador. These cultivars are currently being evaluated in Costa Rica, Honduras, El Salvador, Panama, Guatemala,

[43] As part of The Family Agriculture Program, the government will be providing agricultural inputs (which include seeds and fertilizers), technical assistance and credit support for the cultivation of these crops to approximately 325,000 families in rural zones of El Salvador.

Nicaragua and Haiti. These brown midrib varieties are almost as digestible as corn and are expected to further reduce acreage in silage corn. Also with the sorghum substitution, dairy systems can be more productive in areas with dry climates facing water shortages and more marginal conditions than maize can tolerate.

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LIST OF REFERENCES

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APPENDICES

Appendix A: Distribution of Farmers Interviewed

Table A 1 Distribution of Farmers Interviewed

Departments	Sorghum technologies interviews	Other technologies interviews
Ahuachapán	3	1
Cabañas	8	3
Chalatenango	12	5
Cuscatlán	3	3
La Libertad	7	4
La Paz	4	2
La Unión	5	2
Morazán	6	3
San Miguel	12	3
San Salvador	13	10
San Vicente	21	5
Santa Ana	5	4
Sonsonate	11	6
Usulután	10	4
Total	120	55

Source: Villacís, 2011.

Appendix B: Farm Survey Questionnaire

Farm Survey Questionnaire

Department of Agricultural Economics
Purdue University
West Lafayette, IN 47906
USA

Name of respondent: ____

Relationship to the owner of the farm:_________________________________

Cellphone number: _______________ E-mail:___________________

Region:___________________ Departamento:__________________________

Municipio:_________________ Canton:______________________________

Date of interview Day:______ Month:__________________ Year:_________

Date checked Day:______ Month:__________________ Year:_________

Date entered Day:______ Month:__________________ Year:_________

Distance of the farm from the nearest milk market (Km):

I. Demographic Characteristics of Farmers

1. Name:____

2. Age:________________
3. Sex:________________

4. Level of Education:
__Less than High School
__High School
__College Degree

5. Major Occupation:__________________________

6. Works in the farm? Yes__ No__

7. Years of experience as a rancher:_____

8. Does the hh head participate on on-farm trials? Yes__ No__

9. What type of ranching feeding is used?
   __Feedlot
   __Semi-Feedlot

II. Household Assets

10. Total size of the property (manzanas): Owned________________
Rented_____________

11. Use of land in 2010

Crop or Activity	Area
Sorghum	
Corn	
Pastures for grazing	
Pastures for harvest	
Constructions and Infraestructure	
Other	

12. Livestock Ownership

Type of Animal	Quantity
Bovine Cattle	
Porcine Cattle	
Poultry	
Other	

III. Sorghum Production for the Feeding of the Cattle

13. Season sorghum is grown:
__Rainy Season
__Dry Season
__Both

14. Sorghum Production in the Last Five Years:

VARIETY	YEAR OF ADOPTION	2010		2009		2008		2007		2006	
		AREA	TOTAL PROD. (TM)	AREA	TOTAL PROD. (TM)	AREA	TOTAL PROD. (TM)	AREA	TOTAL PROD. (TM)	AREA	TOTAL PROD. (TM)
SOBERANO											
RCV											
CENTA S-2											
CENTA S-3											
CENTA S-44											

15. Number of Cuts per Cycle of Production of Sorghum

VARIETY	NUMBER OF CUTS PER CYCLE				
	2010	2009	2008	2007	2006
SOBERANO					
RCV					
CENTA S-2					
CENTA S-3					
CENTA S-44					

IV. Adoption of Photo-Insensitive Sorghum Varieties

16. How did you know about the photo-insensitive sorghum varieties?
___From Extension Agents
___From Other Farmers
___From Media
___Other (specify)_____________________________________

17. This year, how many hectares of sorghum are you planting? ________________

18. What is the source of the sorghum variety seeds?
___Retailers
___CENTA
___Other farmers
___NGO's
___Other (specify)_____________________________________

19. Do you save your own seeds from your photo-insensitive sorghum varieties? Yes__ No__

20. If yes, for how many years have you done that continuously? ________

21. If the price of the seed increases, are you willing to pay the higher price? Yes__ No__

22. Do you use fertilizer on sorghum? Yes__ No__
(If not, go to question 24)

23. How many applications do you do per each cycle (cut)?_________________

24. If you do not use fertilizer, what are the reasons for doing so?
___Scarcity
___To much expensive
___Use of organic fertilizer (cattle manure)
___Other (specify)_____________________________________

25. In your opinion what are the advantages of the photo-insensitive sorghum varieties?
___Higher Yields
___Better Grain Quality
___Resistencia a la sequia (disponibilidad todo el año)
___Other (specify)_____________________________________

26. In your opinion what are the disadvantages of the photo-insensitive sorghum varieties?

____
____

27. Sorghum Production Costs in Season 2010

	Unit	Unit Price	Quantity 1st cut	Quantity 2nd cut	Quantity 3rd cut	Quantity 4th cut	Subtotal 1st cut	Subtotal 2nd cut	Subtotal 3rd cut	Subtotal 4th Cut
Item										
Harrow	Obra			-----------	-----------	-----------		-----------	-----------	-----------
Furrow	Obra			-----------	-----------	-----------		-----------	-----------	-----------
Seed				-----------	-----------	-----------		-----------	-----------	-----------
Herbicide				-----------	-----------	-----------		-----------	-----------	-----------
Insecticide										
Formula 15-15-15										
Sulfato de Amonio 21%N										
Urea 46%N										
Labor										
Planting	Day's wage			-----------	-----------	-----------		-----------	-----------	-----------
Application of Herbicides	Day's wage									
Application of Fertilizers 1	Day's wage									
Application of Fertilizers 2	Day's wage									
Weeds Control	Day's wage									
Insects Control	Day's wage									
Birds Control	Day's wage									
Subtotal	--------------	----------	----------	----------	----------	----------				

28. Yields expected per Hectare in Metric Tons

1st Cut:______________ 3rd Cut:____________________

2nd Cut:_____________ 4th Cut:____________________

29. Fertilizer use m the last five years:

Fertilizer Type	Unit	2010				2009				2008				2007				2006			
		1st Cut	2nd Cut	3rd Cut	4th Cut	1st Cut	2nd Cut	3rd Cut	4th Cut	1st Cut	2nd Cut	3rd Cut	4th Cut	1st Cut	2nd Cut	3rd Cut	4th Cut	1st Cut	2nd Cut	3rd Cut	4th Cut
FORMULA 15-15-15																					
SULFATO DE AMONIO 21%N																					
UREA 46%N																					

V. Silage Production

30. When did you start to use silage?___________

31. Which sorghum variety do you use for silage?
____

32. From your actual sorghum production, how many hectares do you use for production of:
Silage____________________
Fresh Cut__________________

33. What type of silage technique do you use?
___De trinchera
___De montón
___Bunker
___Other (specify)________________________

34. Silage production in the last five years (Metric tons).

	2010	2009	2008	2007	2006
Silage Production (MT)					

35. In your opinion what are the advantages of the use of silage as feed for the cattle?

___Higher Production of Milk
___Better Milk Quality
___Disponibility in the dry season
___ Can maintain the same type of feeding the whole year
___Other (specify)________________________

36. In your opinion what are the disadvantages of the use of silage as feed for the cattle?

____

____

37. Silage Capacity (MT):________________

38. Silage Production Costs

	Unit	Quantiy	Unit Price	Subtotal
Black Plastic				
Tape/Glue				
Salt				
Molasses				
Urea				
Labor				
Machinery				
Total				

VI. Cattle Feeding in the Milky Production Season

39. Race and quantity of herd:

Race	Quantity

40. How many cows do you have in milky production in average?________________

41. In average, how many days per year are your cows in milk production? ___________

42. Feed Costs of Herd in the Rainy Season and the Dry Season.

Feed Costs						
Item	**Rainy Season**			**Dry Season**		
	Quantity	Cost Per Unit	Total Cost	Quantity	Cost Per Unit	Total Cost
Concentrate						
Hay						
Fresh Sorghum						
Silage						
Other						
Total Cost						
Average Yield of Milk per Cow per Day						

43. In the rainy season (May-October), milk yields per cow:
__Increase
__Decreases
__Are constant

44. If there is a variation, in average how many liters per cow per day is it?
____

45. Average Price received per liter : Rainy Season_____________
Dry Season_____________

46. If you cannot produce silage, what would be the consequences for your ranch?
__Would Disappear
__Will have to reduce the herd size. In which percentage?_____%
__Nothing. Why?____
__Other (specify)______________________________________

47. What is the cost of renting one hectare for:
    Sorghum production: $________________
    Pastures: $_______________________

48. How much would you ask for one metric ton of:
    Fresh Sorghum: $________________________
    Silage: $___________________________

VII. Crédit and Extension

49. How do you buy inputs?
___Use own funds
___Buy with credit only
___Combination of both

50. Have you taken a loan this year for the production of sorghum? Yes__ No__

51. What are your sources of information about new sorghum technologies:
__Radio
__Extension Agents
__NGO's
__Other farmers
___Other (specify)_________________________

52. How many times have you been visited by an extension agent in the 2010?____________

53. For sorghum production, between which days do you consider the start of the rains as:
Earlier:____
Normal:____
Later:____

Appendix C: Exchange Rate & CPI of El Salvador

Table C 1 Exchange Rate Colon/Dollar

Month	Year							
	1993	1994	1995	1996	1997	1998	1999	2000
Jan	8.70	8.70	8.72	8.72	8.72	8.72	8.72	8.72
Feb	8.76	8.72	8.72	8.72	8.72	8.72	8.72	8.72
Mar	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72
Apr	8.71	8.72	8.72	8.72	8.72	8.72	8.72	8.72
May	8.70	8.72	8.72	8.72	8.72	8.72	8.72	8.72
Jun	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.72
Jul	8.71	8.72	8.72	8.72	8.72	8.72	8.72	8.72
Aug	8.68	8.71	8.72	8.72	8.72	8.72	8.72	8.72
Sep	8.67	8.72	8.72	8.72	8.72	8.72	8.72	8.72
Oct	8.68	8.72	8.72	8.72	8.72	8.72	8.72	8.72
Nov	8.68	8.73	8.72	8.72	8.72	8.72	8.72	8.72
Dec	8.70	8.72	8.72	8.72	8.72	8.72	8.72	8.72

Source: The General Directorate of Statistics and Census of the Ministry of Economy

Table C 2 CPI Base Period Dec 2010 = 100

Month	Year																	
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Jan	0.4758	0.5329	0.5537	0.6213	0.6620	0.6778	0.6990	0.6952	0.7333	0.7394	0.7598	0.7783	0.8228	0.8502	0.8973	0.9399	0.9773	0.9835
Feb	0.4743	0.5153	0.5598	0.6227	0.6711	0.6795	0.6973	0.6986	0.7319	0.7418	0.7617	0.7817	0.8236	0.8544	0.8953	0.9474	0.9787	0.9847
Mar	0.4779	0.5206	0.5660	0.6258	0.6724	0.6825	0.6959	0.6992	0.7334	0.7461	0.7639	0.7867	0.8241	0.8574	0.9008	0.9548	0.9862	0.9879
Apr	0.4801	0.5252	0.5696	0.6281	0.6728	0.6909	0.6920	0.6998	0.7344	0.7488	0.7636	0.7934	0.8283	0.8632	0.9015	0.9627	0.9845	0.9861
May	0.4861	0.5252	0.5736	0.6328	0.6713	0.6945	0.6874	0.7040	0.7355	0.7487	0.7627	0.7990	0.8342	0.8643	0.8978	0.9732	0.9851	0.9840
Jun	0.4991	0.5297	0.5786	0.6426	0.6738	0.6952	0.6869	0.7118	0.7366	0.7535	0.7652	0.8003	0.8345	0.8714	0.9038	0.9853	0.9869	0.9885
Jul	0.5094	0.5337	0.5937	0.6530	0.6791	0.6982	0.6908	0.7110	0.7363	0.7548	0.7624	0.8028	0.8359	0.8823	0.9102	0.9979	0.9853	0.9887
Aug	0.5103	0.5411	0.5978	0.6625	0.6746	0.6897	0.6907	0.7140	0.7389	0.7520	0.7648	0.8046	0.8381	0.8776	0.9088	0.9987	0.9831	0.9871
Sep	0.5104	0.5406	0.6057	0.6585	0.6724	0.6826	0.6925	0.7154	0.7389	0.7493	0.7653	0.8062	0.8416	0.8772	0.9150	0.9944	0.9811	0.9900
Oct	0.5157	0.5467	0.6084	0.6588	0.6702	0.6831	0.6964	0.7153	0.7320	0.7503	0.7677	0.8097	0.8576	0.8738	0.9215	0.9897	0.9739	0.9966
Nov	0.5169	0.5464	0.6111	0.6549	0.6694	0.6981	0.6932	0.7168	0.7385	0.7488	0.7682	0.8099	0.8467	0.8793	0.9340	0.9835	0.9699	1.0011
Dec	0.5220	0.5493	0.6118	0.6568	0.6695	0.6977	0.6906	0.7203	0.7304	0.7509	0.7698	0.8111	0.8457	0.8870	0.9301	0.9810	0.9791	1.0000

Source: The General Directorate of Statistics and Census of the Ministry of Economy

Appendix D: Milk Prices

Table D 1 Milk Producer's Price (Nominal). Dollars/mT

Month	Year																	
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Jan	306.51	350.96	357.80	362.39	405.20	458.72	425.08	425.08	440.00	413.33	480.00	440.00	440.00	426.67	426.67	480.00	520.00	493.33
Feb	330.29	348.62	376.15	363.91	415.90	426.61	429.66	423.55	426.67	413.33	440.00	413.33	440.00	440.00	426.67	453.33	560.00	533.33
Mar	316.51	359.33	365.44	368.50	423.55	422.02	426.61	425.08	440.00	426.67	373.33	426.67	440.00	426.67	453.33	480.00	533.33	493.33
Apr	321.47	353.21	370.03	333.33	422.02	420.49	448.01	435.78	413.33	413.33	400.00	466.67	440.00	413.33	453.33	506.67	533.33	480.00
May	332.57	344.04	370.03	382.26	418.96	423.55	403.67	400.61	413.33	413.33	400.00	413.33	413.33	386.67	440.00	480.00	520.00	453.33
Jun	293.58	337.92	327.22	353.21	397.55	417.43	370.03	397.55	373.33	373.33	386.67	400.00	373.33	373.33	466.67	426.67	480.00	453.33
Jul	315.35	327.22	307.34	340.98	377.68	363.91	371.56	380.73	373.33	400.00	373.33	386.67	386.67	373.33	413.33	480.00	453.33	400.00
Aug	301.08	319.94	316.51	370.03	383.79	376.15	359.33	365.44	373.33	400.00	373.33	386.67	426.67	373.33	400.00	466.67	493.33	453.33
Sep	299.88	322.63	327.22	359.33	380.73	386.85	357.80	362.39	386.67	400.00	360.00	386.67	386.67	373.33	413.33	426.67	453.33	413.33
Oct	348.69	325.69	336.39	363.91	374.62	388.38	366.97	359.33	360.00	400.00	360.00	400.00	386.67	373.33	386.67	466.67	480.00	466.67
Nov	331.80	343.64	348.62	366.97	405.20	394.50	380.73	392.97	400.00	400.00	386.67	400.00	413.33	426.67	453.33	493.33	480.00	466.67
Dec	338.70	356.27	374.62	406.73	414.37	399.08	382.26	415.90	413.33	400.00	386.67	413.33	440.00	440.00	453.33	506.67	506.67	480.00
AVERAGE	319.70	340.79	348.11	364.30	401.63	406.47	393.48	398.70	401.11	404.44	393.33	411.11	415.56	402.22	432.22	472.22	501.11	465.56

Source: The General Directorate of Statistics and Census of the Ministry of Economy. 1 mT = 1000 liter

Table D 2 Milk Producer's Price (Real, CPI=2010). Dollars/mT

Month	Year																	
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Jan	644.25	658.52	646.19	583.30	612.08	676.81	608.11	611.45	600.04	558.97	631.73	565.32	534.78	501.85	475.51	510.70	532.09	501.63
Feb	696.38	676.51	671.96	584.38	619.73	627.80	616.14	606.26	582.95	557.20	577.67	528.73	534.27	514.98	476.55	478.49	572.21	541.61
Mar	662.27	690.20	645.61	588.88	629.92	618.37	613.05	607.94	599.96	571.86	488.70	542.32	533.89	497.61	503.25	502.74	540.80	499.40
Apr	669.62	672.51	649.67	530.68	627.28	608.62	647.45	622.73	562.85	551.96	523.81	588.19	531.24	478.83	502.87	526.30	541.71	486.77
May	684.09	655.04	645.12	604.06	624.10	609.85	587.28	569.05	561.95	552.10	524.48	517.33	495.47	447.38	490.10	493.23	527.86	460.69
Jun	588.25	637.93	565.56	549.65	589.98	600.45	538.72	558.49	506.83	495.43	505.31	499.84	447.36	428.41	516.37	433.03	486.38	458.59
Jul	619.00	613.07	517.71	522.18	556.11	521.20	537.88	535.52	507.03	529.93	489.71	481.65	462.58	423.13	454.11	480.99	460.09	404.56
Aug	589.96	591.30	529.49	558.55	568.89	545.37	520.25	511.83	505.28	531.93	488.14	480.59	509.06	425.40	440.12	467.26	501.83	459.27
Sep	587.52	596.82	540.23	545.70	566.25	566.76	516.71	506.58	523.33	533.80	470.40	479.60	459.46	425.59	451.73	429.06	462.07	417.50
Oct	676.14	595.78	552.88	552.42	558.94	568.59	526.98	502.37	491.80	533.11	468.90	494.04	450.85	427.26	419.62	471.51	492.89	468.27
Nov	641.91	628.96	570.50	560.31	605.28	565.07	549.21	548.20	541.66	534.15	503.32	493.92	488.19	485.25	485.36	501.63	494.88	466.16
Dec	648.87	648.59	612.35	619.25	618.89	571.97	553.53	577.43	565.87	532.69	502.29	509.58	520.29	496.05	487.41	516.48	517.46	480.00
AVERAGE	642.35	638.77	595.61	566.61	598.12	590.07	567.94	563.15	545.80	540.26	514.54	515.09	497.28	462.64	475.25	484.29	510.86	470.37

Source: The General Directorate of Statistics and Census of the Ministry of Economy. 1 mT = 1000 liter

Table D 3 Milk Consumer's Price (Nominal). Dollars/mT

Month	Year																	
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Jan	459.77	498.08	496.94	496.94	535.17	496.94	496.94	496.94	493.33	466.67	493.33	453.33	453.33	453.33	533.33	666.67	666.67	600.00
Feb	456.62	496.94	496.94	496.94	535.17	496.94	496.94	496.94	493.33	453.33	493.33	453.33	453.33	453.33	533.33	666.67	666.67	600.00
Mar	458.72	496.94	496.94	496.94	535.17	496.94	458.72	496.94	493.33	466.67	493.33	453.33	453.33	453.33	533.33	666.67	666.67	600.00
Apr	459.24	496.94	496.94	504.59	496.94	496.94	458.72	481.65	493.33	493.33	493.33	453.33	453.33	453.33	533.33	666.67	666.67	666.67
May	498.08	496.94	496.94	504.59	496.94	496.94	458.72	458.72	493.33	453.33	493.33	453.33	453.33	453.33	533.33	666.67	666.67	666.67
Jun	458.72	496.94	458.72	496.94	496.94	496.94	458.72	466.36	453.33	453.33	453.33	453.33	453.33	453.33	533.33	600.00	600.00	666.67
Jul	420.97	458.72	458.72	496.94	458.72	496.94	458.72	458.72	453.33	480.00	453.33	453.33	453.33	453.33	533.33	600.00	600.00	666.67
Aug	460.83	459.24	458.72	535.17	458.72	458.72	458.72	458.72	453.33	480.00	453.33	453.33	453.33	453.33	533.33	600.00	600.00	666.67
Sep	461.36	458.72	458.72	535.17	496.94	458.72	458.72	466.36	453.33	453.33	453.33	453.33	453.33	453.33	533.33	666.67	600.00	666.67
Oct	460.83	458.72	458.72	535.17	496.94	496.94	458.72	474.01	493.33	453.33	493.33	453.33	453.33	453.33	533.33	666.67	600.00	666.67
Nov	499.23	458.19	458.72	535.17	496.94	504.59	458.72	496.94	493.33	480.00	493.33	453.33	453.33	533.33	666.67	666.67	600.00	666.67
Dec	498.08	458.72	458.72	535.17	496.94	504.59	458.72	496.94	493.33	480.00	493.33	453.33	453.33	533.33	666.67	666.67	600.00	666.67
AVERAGE	466.04	477.92	474.64	514.14	500.13	491.85	465.09	479.10	480.00	467.78	480.00	453.33	453.33	466.67	555.56	650.00	627.78	650.00

Source: The General Directorate of Statistics and Census of the Ministry of Economy. 1 mT = 1000 liter

Table D 4 Milk Consumer's Price (Real, CPI=2010). Dollars/mT

Month	Year																	
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Jan	966.38	934.58	897.48	799.88	808.41	733.21	710.92	714.83	672.78	631.10	649.28	582.45	550.98	533.21	594.38	709.31	682.16	610.10
Feb	962.73	964.33	887.75	798.00	797.44	731.31	712.62	711.32	674.04	611.13	647.69	579.90	550.46	530.59	595.68	703.67	681.21	609.31
Mar	959.82	954.54	877.92	794.13	795.93	728.16	659.19	710.72	672.69	625.47	645.78	576.22	550.06	528.71	592.06	698.25	676.00	607.37
Apr	956.61	946.17	872.49	803.33	738.65	719.28	662.92	688.28	671.79	658.79	646.03	571.38	547.33	525.17	591.61	692.50	677.14	676.07
May	1024.56	946.17	866.38	797.36	740.27	715.53	667.36	651.58	670.72	605.53	646.86	567.39	543.41	524.51	594.06	685.05	676.74	677.48
Jun	919.14	938.13	792.84	773.32	737.47	714.83	667.83	655.15	615.43	601.60	592.44	566.49	543.22	520.21	590.13	608.94	607.98	674.39
Jul	826.33	859.45	772.70	761.02	675.44	711.72	664.05	645.21	615.68	635.91	594.64	564.69	542.33	513.80	585.94	601.24	608.94	674.26
Aug	903.00	848.76	767.38	807.81	679.95	665.09	664.14	642.47	613.56	638.31	592.74	563.45	540.88	516.56	586.83	600.76	610.34	675.40
Sep	903.87	848.55	757.33	812.74	739.08	672.05	662.45	651.92	613.56	604.98	592.36	562.29	538.67	516.79	582.87	670.41	611.56	673.39
Oct	893.57	839.13	753.92	812.38	741.46	727.53	658.73	662.70	673.95	604.19	642.57	559.91	528.59	518.81	578.78	673.59	616.11	668.96
Nov	965.84	838.62	750.66	817.11	742.32	722.77	661.70	693.25	668.05	640.98	642.16	559.77	535.43	606.56	713.77	677.88	618.59	665.95
Dec	954.22	835.09	749.82	814.80	742.22	723.18	664.24	689.95	675.39	639.23	640.86	558.90	536.05	601.27	716.78	679.58	612.78	666.67
AVERAGE	936.34	896.13	812.22	799.32	744.89	713.72	671.35	676.45	653.13	624.77	627.79	567.74	542.29	536.35	610.24	666.76	639.96	656.61

Source: The General Directorate of Statistics and Census of the Ministry of Economy. 1 mT = 1000 liter

Appendix E: Milk Production in El Salvador

Table E 1 Milk Production in El Salvador (mT)

Year	National	By Farm Size		
	Total Production	Small Farmers (15%)	Medium Farmers (45%)	Large Farmers (40%)
1993	325,300	48,795	146,385	130,120
1994	319,200	47,880	143,640	127,680
1995	282,000	42,300	126,900	112,800
1996	317,451	47,618	142,853	126,980
1997	356,400	53,460	160,380	142,560
1998	331,470	49,721	149,162	132,588
1999	349,390	52,409	157,226	139,756
2000	380,106	57,016	171,048	152,042
2001	383,467	57,520	172,560	153,387
2002	399,280	59,892	179,676	159,712
2003	392,170	58,826	176,477	156,868
2004	398,191	59,729	179,186	159,276
2005	448,752	67,313	201,938	179,501
2006	435,413	65,312	195,936	174,165
2007	475,862	71,379	214,138	190,345
2008	494,071	74,111	222,332	197,628
2009	541,614	81,242	243,726	216,646
2010	541,614	81,242	243,726	216,646

Source: The General Directorate of Agricultural Economics (DGEA) of the Ministry of Agriculture and Livestock

Appendix F: Sorghum Planting Seasons in El Salvador

Sorghum in El Salvador is mainly grown under rain-fed situation although it is also widely planted under irrigation or residual moisture (no later than early December). Primera (the first) refers when planting is done right after the rains started (between the second half of May and early June) using photo-insensitive materials, in this way farmers are allowed to obtain various cuts, either managing regrowth or planting new seeds; this planting season is not the most recommended for grain production because the rains can ruin the grain, but it is proper for silage production, using the grain when it is in a matter-milky state. Postrera (the last) refers when planting is done in the first half of August and it is the most recommended planting season for grain production.

Photoperiod is an important factor to consider when planting because it limits growing; forage sorghums CENTA SS-44, CENTA S-2 and CENTA S-3 are affected in their performance when grown in short days (November, December and January). CENTA Soberano and CENTA RCV (dual-purpose materials), despite these adverse conditions, are less affected. For association with maize (partnership), sorghum is planted during the first half of June, coinciding with the maize earthing up (30-35 days after its seeding), or in the first half of August when the maize was doubled.

Appendix G: Agronomic Characteristics of Photo-Insensitive Sorghums

Table G 1 Agronomic Characteristics of Sorghum Varieties Generated by CENTA

	CENTA Soberano	CENTA RCV	CENTA - S2	CENTA - S3
Plant height (m)	1.4	1.8	2.6	2.7
Days to flower, planting in August in monoculture system	65	70	70	65
Days to harvest, planting in August	100	110	100	100
Grain yields (Kg/ha)	5,125	5,125	4,484	3,203
Green matter Yields (biomass) (MT/ha)	-	50	71	109

Source: CENTA, 2007.

Table G 2 Agronomic and Nutritional Characteristics of Hybrid CENTA SS-44

Characteristic	CENTA SS-44
Plant height (m)	2.8
Days to flower	57
Days to harvest	53
Green matter yields per cut (MT/ha)	43-50
Dry matter yields per cut (MT/ha)	13
Crude protein (%)	17
Digestible protein (%)	6.26
Total digestible nutrients (%)	53.33
Acid detergent fiber (%)	40
Neutral detergent fiber (%)	61.44
Dry matter digestibility (%)	58.31

Source: CENTA, 2007.

Appendix H: Areas Planted with Sorghum in El Salvador

Table H 1 Area Planted with Sorghum in El Salvador (Ha)

Year	National Total Area	Area with other varieties	Area with the new technologies					Area reported with certified seeds
			S-2	RCV	S-3	SS-44	Total	
1994	121,660	119,560	2,100	-	-	-	2,100	6,217
1995	134,260	131,715	2,545	-	-	-	2,545	8,663
1996	119,420	116,429	2,991	-	-	-	2,991	13,170
1997	124,408	120,411	3,436	560	-	-	3,996	19,190
1998	109,340	104,268	3,882	1,190	-	-	5,072	13,017
1999	106,365	100,218	4,327	1,820	-	-	6,147	19,373
2000	93,940	86,717	4,773	2,450	-	-	7,223	11,025
2001	97,460	89,161	5,218	3,080	-	-	8,298	12,978
2002	76,387	67,013	5,664	3,710	-	-	9,374	10,760
2003	88,322	77,873	6,109	4,340	-	-	10,449	8,949
2004	102,323	90,623	6,555	4,970	175	-	11,700	12,845
2005	86,563	72,534	7,000	5,600	1,429	-	14,029	7,198
2006	64,436	46,282	7,840	6,580	2,683	1,050	18,153	11,408
2007	84,440	62,793	8,680	7,560	3,938	1,470	21,648	14,429
2008	96,670	71,948	9,520	8,540	5,192	1,470	24,722	20,225
2009	95,642	67,847	10,360	9,520	6,446	1,470	27,796	24,633
2010	93,800	62,930	11,200	10,500	7,700	1,470	30,870	29,041

Source: Villacis, 2011

Table H 2 Area Used for Forage & Silage with New Sorghum Technologies (Ha)

Year	S-2	RCV	S-3	SS-44	Total
1994	1,969	-	-	-	1,969
1995	2,386	-	-	-	2,386
1996	2,804	-	-	-	2,804
1997	3,222	149	-	-	3,371
1998	3,639	317	-	-	3,957
1999	4,057	485	-	-	4,542
2000	4,474	653	-	-	5,128
2001	4,892	821	-	-	5,713
2002	5,310	989	-	-	6,299
2003	5,727	1,157	-	-	6,885
2004	6,145	1,325	127	-	7,597
2005	6,563	1,493	1,039	-	9,095
2006	7,350	1,755	1,952	1,050	12,106
2007	8,138	2,016	2,864	1,470	14,487
2008	8,925	2,277	3,776	1,470	16,448
2009	9,713	2,539	4,688	1,470	18,409
2010	10,500	2,800	5,600	1,470	20,370

Source: Villacis, 2011.

Appendix I: Area of Sorghum and Milk Production by Farm Size Using New Tech.

Table I 1 Area Planted, Number of Producers and Milk Production by Small Farmers Using New Sorghum Technologies

Year	Area Planted under New Tech by Small Farmers (Ha)	Number of Small Farms Using New Tech	Milk Produced Under New Tech bySsmall Farms (mT)
1993	-	-	-
1994	394	165	3,974
1995	477	200	4,817
1996	561	234	5,660
1997	674	282	6,804
1998	791	331	7,986
1999	908	380	9,168
2000	1,026	429	10,350
2001	1,143	478	11,532
2002	1,260	527	12,714
2003	1,377	576	13,896
2004	1,519	635	15,335
2005	1,819	761	18,358
2006	2,421	1,012	24,435
2007	2,897	1,211	29,241
2008	3,290	1,375	33,199
2009	3,682	1,539	37,157
2010	4,074	1,703	41,115

Source: Villacis, 2011.

Table I 2 Area Planted, Number of Producers and Milk Production by Medium Farmers Using New Sorghum Technologies

Year	Area Planted under New Tech by Medium Farmers (Ha)	Number of Medium Farms Using New Tech	Milk Produced Under New Tech by Medium Farms (mT)
1993	-	-	-
1994	984	119	15,957
1995	1,193	144	19,341
1996	1,402	169	22,726
1997	1,685	203	27,321
1998	1,978	238	32,068
1999	2,271	274	36,814
2000	2,564	309	41,560
2001	2,857	344	46,307
2002	3,149	379	51,053
2003	3,442	415	55,799
2004	3,799	457	61,577
2005	4,548	548	73,716
2006	6,053	729	98,120
2007	7,244	872	117,418
2008	8,224	990	133,311
2009	9,205	1,108	149,204
2010	10,185	1,227	165,098

Source: Villacis, 2011.

Table I 3 Area Planted, Number of Producers and Milk Production by Large Farmers Using New Sorghum Technologies

Year	Area Planted under New Tech by Large Farmers (Ha)	Number of Large Farms Using New Tech	Milk Produced Under New Tech by Large Farms (mT)
1993	-	-	-
1994	591	38	14,891
1995	716	46	18,050
1996	841	55	21,209
1997	1,011	66	25,497
1998	1,187	77	29,927
1999	1,363	88	34,356
2000	1,538	100	38,786
2001	1,714	111	43,215
2002	1,890	123	47,644
2003	2,065	134	52,074
2004	2,279	148	57,466
2005	2,729	177	68,795
2006	3,632	236	91,569
2007	4,346	282	109,578
2008	4,934	320	124,410
2009	5,523	359	139,243
2010	6,111	397	154,075

Source: Villacis, 2011

Appendix J: Parameter ν for each Farm Size

Table J 1 Parameter ν for each Farm Size

Year	ν (Small Farmers)	ν (Medium Farmers)	ν (Large Farmers)	ν (Aggregated)
1993	-	-	-	-
1994	0.05	0.29	0.27	0.61
1995	0.07	0.40	0.37	0.84
1996	0.07	0.42	0.39	0.87
1997	0.08	0.44	0.41	0.93
1998	0.10	0.56	0.52	1.18
1999	0.10	0.61	0.57	1.28
2000	0.11	0.63	0.59	1.33
2001	0.12	0.70	0.65	1.47
2002	0.13	0.74	0.69	1.56
2003	0.14	0.83	0.77	1.73
2004	0.15	0.90	0.83	1.88
2005	0.16	0.95	0.89	2.00
2006	0.22	1.31	1.21	2.74
2007	0.24	1.43	1.33	3.00
2008	0.27	1.57	1.45	3.29
2009	0.27	1.60	1.48	3.35
2010	0.30	1.77	1.64	3.71

Source: Villacis, 2011.

Appendix K: Research, Extension and Transfer Costs Estimates

Table K 1 Research Cost Estimates Based on 2010 Prices (US$)

Year	Generation and Evaluation				Land Rental				Office	Total
	S-2	RCV	S-3	SS-44	S-2	RCV	S-3	SS-44	Rental	Cost
1993	110,700	27,675	-	-	11,852	2,963	-	-	7,200	160,391
1994	1,500	27,675	-	-	375	2,963	-	-	7,200	39,713
1995	1,500	27,675	-	-	375	2,963	-	-	7,200	39,713
1996	-	27,675	-	-	-	2,963	-	-	7,200	37,838
1997	-	-	-	-	-	-	-	-	7,200	7,200
1998	-	-	-	-	-	-	-	-	7,200	7,200
1999	1,500	-	-	-	375	-	-	-	7,200	9,075
2000	1,500	-	-	-	375	-	-	-	7,200	9,075
2001	-	1,500	6,667	12,120	-	375	357	1,000	7,200	29,218
2002	-	1,500	6,667	12,120	-	375	357	1,000	7,200	29,218
2003	1,500	-	6,667	12,120	375	-	357	1,000	7,200	29,218
2004	1,500	-	-	12,120	375	-	-	1,000	7,200	22,194
2005	-	-	-	12,120	-	-	-	1,000	7,200	20,320
2006	-	1,500	-	-	-	375	-	-	7,200	9,075
2007	1,500	1,500	1,500	-	375	375	375	-	7,200	12,825
2008	1,500	-	1,500		375		375	-	7,200	10,950
2009	-	-	-	1,000	-	-	-	268	7,200	8,468
2010	-	-	-	1,000	-	-	-	268	7,200	8,468

Source: Author's computation based on information provided by Clara, 2011

Table K 2 Extension and Transfer Cost Estimates Based on 2010 Prices (US$)

Year	Cost of Transfer				Israeli	Proleche	Total
	S-2	RCV	S-3	SS-44	Extension	Extension	Cost
1993	17,190	-	-	-	150,000	24,000	191,190
1994	-	-	-	-	150,000	24,000	174,000
1995	-	-	-	-	150,000	24,000	174,000
1996	-	17,190	-	-	150,000	24,000	191,190
1997	-	-	-	-	150,000	24,000	174,000
1998	-	-	-	-	150,000	24,000	174,000
1999	-	-	-	-	150,000	24,000	174,000
2000	-	-	-	-	150,000	24,000	174,000
2001	-	-	-	-	150,000	24,000	174,000
2002	-	-	-	-	150,000	24,000	174,000
2003	-	-	17,190	-	150,000	24,000	191,190
2004	-	-	-	-	150,000	24,000	174,000
2005	-	-	-	17,190	-	24,000	41,190
2006	-	-	-	-	-	24,000	24,000
2007	-	-	-	-	-	24,000	24,000
2008	-	-	-	-	-	24,000	24,000
2009	-	-	-	-	-	24,000	24,000
2010	-	-	-	-	-	24,000	24,000

Source: Author’s computation based on information provided by CENTA, 2011.

Table K 3 Total Research and Extension Cost Estimates Based on 2010 Prices (US$)

Year	Total Research Cost	Total Extension and Transfer Cost	Total Investment
1993	160,391	191,190	351,581
1994	39,713	174,000	213,713
1995	39,713	174,000	213,713
1996	37,838	191,190	229,028
1997	7,200	174,000	181,200
1998	7,200	174,000	181,200
1999	9,075	174,000	183,075
2000	9,075	174,000	183,075
2001	29,218	174,000	203,218
2002	29,218	174,000	203,218
2003	29,218	191,190	220,408
2004	22,194	174,000	196,194
2005	20,320	41,190	61,510
2006	9,075	24,000	33,075
2007	12,825	24,000	36,825
2008	10,950	24,000	34,950
2009	8,468	24,000	32,468
2010	8,468	24,000	32,468
Total	490,157	2,300,760	2,790,917

Source: Author’s computation, 2011.

Appendix L: Private and Net Benefits (Parallel Shift)

Table L 1 Private Benefits per Year for Different Groups of the Society (Parallel S.)

Year	Small Farmers Gain	Medium Farmers Gain	Large Farmers Gain	Total Producer's Gain	Total Processor's Gain	Total Consumer's Gain
1993	-	-	-	-	-	-
1994	9,608	56,625	52,603	118,834	2,777	75,440
1995	11,727	69,117	64,208	145,048	3,060	90,433
1996	13,665	80,536	74,815	169,011	4,026	107,678
1997	16,923	99,740	92,656	209,314	2,979	123,319
1998	19,994	117,837	109,468	247,290	3,006	143,124
1999	23,070	135,964	126,308	285,330	3,013	162,866
2000	25,952	152,954	142,091	320,984	3,746	184,996
2001	28,940	170,563	158,449	357,935	4,083	205,824
2002	32,145	189,449	175,994	397,566	3,607	223,973
2003	34,723	204,643	190,109	429,449	5,483	249,865
2004	39,165	230,821	214,428	484,381	2,872	265,266
2005	46,989	276,930	257,262	581,138	3,051	316,280
2006	61,746	363,894	338,050	763,608	7,057	430,828
2007	72,220	425,617	395,390	893,127	14,717	536,210
2008	80,640	475,238	441,487	997,247	21,799	625,545
2009	92,295	543,924	505,295	1,141,379	16,734	674,887
2010	99,528	586,544	544,889	1,230,791	28,272	778,875
Total	709,330	4,180,398	3,883,500	8,772,432	130,280	5,195,411

Source: Villacis, 2011

Table L 2 Net Benefits per Year to the Society (Parallel Shift)

Year	Privet Net Benefits	Total Research Costs	Net Benefits to the Society
1993	-	351,581	(351,581)
1994	197,051	213,713	(16,661)
1995	238,541	213,713	24,828
1996	280,715	229,028	51,687
1997	335,612	181,200	154,412
1998	393,420	181,200	212,220
1999	451,210	183,075	268,135
2000	509,726	183,075	326,651
2001	567,842	203,218	364,624
2002	625,147	203,218	421,929
2003	684,797	220,408	464,389
2004	752,519	196,194	556,324
2005	900,469	61,510	838,959
2006	1,201,493	33,075	1,168,418
2007	1,444,054	36,825	1,407,229
2008	1,644,591	34,950	1,609,641
2009	1,833,000	32,468	1,800,532
2010	2,037,938	32,468	2,005,470
Total	14,098,124	2,790,917	11,307,206

Source: Villacis, 2011

Appendix M: Private and Net Benefits (Pivotal Shift)

Table M 1 Private Benefits per Year for Different Groups of the Society (Pivotal S.)

Year	Small Farmers Gain	Medium Farmers Gain	Large Farmers Gain	Total Producer's Gain	Total Processor's Gain	Total Consumer's Gain
1993	-	-	-	-	-	-
1994	1,754	10,338	9,604	21,694	2,777	75,440
1995	2,208	13,011	12,087	27,302	3,060	90,433
1996	2,479	14,611	13,574	30,660	4,026	107,678
1997	3,476	20,487	19,032	42,989	2,979	123,319
1998	4,211	24,816	23,053	52,071	3,006	143,124
1999	4,951	29,174	27,102	61,216	3,013	162,866
2000	5,497	32,396	30,095	67,975	3,746	184,996
2001	6,149	36,236	33,663	76,031	4,083	205,824
2002	7,018	41,354	38,417	86,768	3,607	223,973
2003	7,260	42,780	39,742	89,756	5,483	249,865
2004	8,858	52,197	48,491	109,513	2,872	265,266
2005	10,707	63,093	58,613	132,370	3,051	316,280
2006	13,454	79,267	73,639	166,277	7,057	430,828
2007	14,430	85,012	78,976	178,317	14,717	536,210
2008	15,027	88,529	82,244	185,682	21,799	625,545
2009	18,860	111,111	103,223	233,059	16,734	674,887
2010	18,271	107,627	99,987	225,715	28,272	778,875
Total	144,610	852,039	791,543	1,787,395	130,280	5,195,411

Source: Villacis, 2011

Table M 2 Net Benefits per Year to the Society (Pivotal Shift)

Year	Privet Net Benefits	Total Research Costs	Net Benefits to the Society
1993	-	351,581	(351,581)
1994	99,911	213,713	(113,802)
1995	120,795	213,713	(92,918)
1996	142,364	229,028	(86,664)
1997	169,287	181,200	(11,913)
1998	198,200	181,200	17,000
1999	227,095	183,075	44,020
2000	256,717	183,075	73,642
2001	285,939	203,218	82,721
2002	314,348	203,218	111,130
2003	345,104	220,408	124,695
2004	377,651	196,194	181,456
2005	451,701	61,510	390,192
2006	604,162	33,075	571,087
2007	729,244	36,825	692,420
2008	833,025	34,950	798,076
2009	924,680	32,468	892,212
2010	1,032,862	32,468	1,000,394
Total	7,113,087	2,790,917	4,322,169

Source: Villacis, 2011.

Appendix N: Sensitivity Analysis Using Different Supply and Demand Elasticities

Table N 1 Sensitivity Analysis: Private Net Benefits (Parallel Shift)

Elasticity of Supply	Elasticity of Demand										
	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
0.00	$ -	$ 13,970,074	$ 13,970,074	$ 13,970,074	$ 13,970,074	$ 13,970,074	$ 13,970,074	$ 13,970,074	$ 13,970,074	$ 13,970,074	$ 13,970,074
0.10	$ 13,970,074	$ 13,968,451	$ 13,967,843	$ 13,967,525	$ 13,967,330	$ 13,967,197	$ 13,967,101	$ 13,967,029	$ 13,966,972	$ 13,966,927	$ 13,966,890
0.20	$ 13,970,074	$ 13,967,971	$ 13,966,827	$ 13,966,107	$ 13,965,612	$ 13,965,251	$ 13,964,976	$ 13,964,760	$ 13,964,585	$ 13,964,441	$ 13,964,320
0.30	$ 13,970,074	$ 13,967,742	$ 13,966,245	$ 13,965,203	$ 13,964,436	$ 13,963,847	$ 13,963,381	$ 13,963,004	$ 13,962,691	$ 13,962,428	$ 13,962,203
0.40	$ 13,970,074	$ 13,967,607	$ 13,965,869	$ 13,964,577	$ 13,963,580	$ 13,962,786	$ 13,962,140	$ 13,961,603	$ 13,961,151	$ 13,960,764	$ 13,960,429
0.50	$ 13,970,074	$ 13,967,519	$ 13,965,605	$ 13,964,118	$ 13,962,929	$ 13,961,956	$ 13,961,146	$ 13,960,461	$ 13,959,874	$ 13,959,365	$ 13,958,920
0.60	$ 13,970,074	$ 13,967,456	$ 13,965,410	$ 13,963,766	$ 13,962,417	$ 13,961,289	$ 13,960,333	$ 13,959,511	$ 13,958,798	$ 13,958,173	$ 13,957,621
0.70	$ 13,970,074	$ 13,967,409	$ 13,965,260	$ 13,963,488	$ 13,962,004	$ 13,960,741	$ 13,959,655	$ 13,958,709	$ 13,957,880	$ 13,957,145	$ 13,956,491
0.80	$ 13,970,074	$ 13,967,373	$ 13,965,140	$ 13,963,264	$ 13,961,664	$ 13,960,283	$ 13,959,081	$ 13,958,023	$ 13,957,086	$ 13,956,250	$ 13,955,499
0.90	$ 13,970,074	$ 13,967,345	$ 13,965,044	$ 13,963,078	$ 13,961,378	$ 13,959,895	$ 13,958,588	$ 13,957,429	$ 13,956,393	$ 13,955,462	$ 13,954,621
1.00	$ 13,970,074	$ 13,967,321	$ 13,964,963	$ 13,962,921	$ 13,961,136	$ 13,959,561	$ 13,958,161	$ 13,956,910	$ 13,955,784	$ 13,954,765	$ 13,953,839

Source: Villacis, 2011

Table N 2 Sensitivity Analysis: Distribution of Benefits (Parallel Shift)

Elasticity of Supply	Elasticity of Demand											
	0.00		0.10		0.20		0.30		0.40		0.50	
	Consumers	Producers	Consumers	Producers	Consumers	Producers	Consumers	Producers	Consumers	Producers	Consumers	Producers
0.00	$ -	$ -	$ -	$ 13,970,074	$ -	$ 13,970,074	$ -	$ 13,970,074	$ -	$ 13,970,074	$ -	$ 13,970,074
0.10	$ 13,970,074	$ -	$ 7,572,596	$ 6,395,855	$ 5,195,411	$ 8,772,432	$ 3,954,358	$ 10,013,167	$ 3,191,956	$ 10,775,373	$ 2,676,042	$ 11,291,156
0.20	$ 13,970,074	$ -	$ 9,819,506	$ 4,148,466	$ 7,571,712	$ 6,395,115	$ 6,161,721	$ 7,804,386	$ 5,194,576	$ 8,771,036	$ 4,489,916	$ 9,475,336
0.30	$ 13,970,074	$ -	$ 10,897,807	$ 3,069,935	$ 8,934,350	$ 5,031,896	$ 7,570,828	$ 6,394,375	$ 6,568,586	$ 7,395,850	$ 5,800,780	$ 8,163,068
0.40	$ 13,970,074	$ -	$ 11,531,084	$ 2,436,523	$ 9,818,024	$ 4,147,845	$ 8,548,523	$ 5,416,054	$ 7,569,944	$ 6,393,636	$ 6,792,512	$ 7,170,274
0.50	$ 13,970,074	$ -	$ 11,947,721	$ 2,019,797	$ 10,437,552	$ 3,528,053	$ 9,266,675	$ 4,697,443	$ 8,332,204	$ 5,630,725	$ 7,569,060	$ 6,392,896
0.60	$ 13,970,074	$ -	$ 12,242,652	$ 1,724,804	$ 10,895,984	$ 3,069,426	$ 9,816,542	$ 4,147,224	$ 8,931,893	$ 5,030,524	$ 8,193,632	$ 5,767,657
0.70	$ 13,970,074	$ -	$ 12,462,409	$ 1,505,000	$ 11,248,930	$ 2,716,330	$ 10,251,081	$ 3,712,407	$ 9,416,020	$ 4,545,984	$ 8,706,880	$ 5,253,862
0.80	$ 13,970,074	$ -	$ 12,632,486	$ 1,334,887	$ 11,529,044	$ 2,436,096	$ 10,603,137	$ 3,360,127	$ 9,815,060	$ 4,146,604	$ 9,136,140	$ 4,824,144
0.90	$ 13,970,074	$ -	$ 12,768,018	$ 1,199,326	$ 11,756,764	$ 2,208,280	$ 10,894,161	$ 3,068,917	$ 10,149,636	$ 3,811,742	$ 9,500,473	$ 4,459,422
1.00	$ 13,970,074	$ -	$ 12,878,561	$ 1,088,760	$ 11,945,533	$ 2,019,431	$ 11,138,759	$ 2,824,162	$ 10,434,205	$ 3,526,931	$ 9,813,578	$ 4,145,983

Source: Villacis, 2011

Elasticity of Supply	Elasticity of Demand									
	0.60		0.70		0.80		0.90		1.00	
	Consumers	Producers	Consumers	Producers	Consumers	Producers	Consumers	Producers	Consumers	Producers
0.00	$ -	$ 13,970,074	$ -	$ 13,970,074	$ -	$ 13,970,074	$ -	$ 13,970,074	$ -	$ 13,970,074
0.10	$ 2,303,706	$ 11,663,396	$ 2,022,330	$ 11,944,699	$ 1,802,211	$ 12,164,762	$ 1,625,306	$ 12,341,620	$ 1,480,028	$ 12,486,861
0.20	$ 3,953,631	$ 10,011,345	$ 3,531,805	$ 10,432,955	$ 3,191,324	$ 10,773,261	$ 2,910,725	$ 11,053,716	$ 2,675,486	$ 11,288,834
0.30	$ 5,193,741	$ 8,769,640	$ 4,701,749	$ 9,261,254	$ 4,294,922	$ 9,667,768	$ 3,952,905	$ 10,009,523	$ 3,661,349	$ 10,300,854
0.40	$ 6,159,962	$ 7,802,178	$ 5,635,230	$ 8,326,373	$ 5,192,907	$ 8,768,244	$ 4,814,987	$ 9,145,777	$ 4,488,355	$ 9,472,074
0.50	$ 6,934,057	$ 7,027,089	$ 6,397,404	$ 7,563,057	$ 5,937,886	$ 8,021,988	$ 5,539,981	$ 8,419,384	$ 5,192,072	$ 8,766,848
0.60	$ 7,568,177	$ 6,392,156	$ 7,031,492	$ 6,928,020	$ 6,565,921	$ 7,392,877	$ 6,158,202	$ 7,799,971	$ 5,798,179	$ 8,159,442
0.70	$ 8,097,154	$ 5,862,501	$ 7,567,293	$ 6,391,417	$ 7,102,560	$ 6,855,320	$ 6,691,635	$ 7,265,510	$ 6,325,682	$ 7,630,809
0.80	$ 8,545,147	$ 5,413,934	$ 8,026,026	$ 5,931,997	$ 7,566,409	$ 6,390,677	$ 7,156,613	$ 6,799,636	$ 6,788,950	$ 7,166,549
0.90	$ 8,929,436	$ 5,029,152	$ 8,423,210	$ 5,534,219	$ 7,971,345	$ 5,985,048	$ 7,565,525	$ 6,389,937	$ 7,199,050	$ 6,755,571
1.00	$ 9,262,711	$ 4,695,451	$ 8,770,456	$ 5,186,454	$ 8,327,925	$ 5,627,859	$ 7,927,939	$ 6,026,825	$ 7,564,641	$ 6,389,197

Source: Villacis, 2011

Table N 3 Sensitivity Analysis: Private Net Benefits (Pivotal Shift)

Elasticity of Supply	Elasticity of Demand										
	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
0.00	$ -	$ 6,985,037	$ 6,985,037	$ 6,985,037	$ 6,985,037	$ 6,985,037	$ 6,985,037	$ 6,985,037	$ 6,985,037	$ 6,985,037	$ 6,985,037
0.10	$ 6,985,037	$ 6,983,413	$ 6,982,806	$ 6,982,488	$ 6,982,293	$ 6,982,160	$ 6,982,064	$ 6,981,992	$ 6,981,935	$ 6,981,890	$ 6,981,853
0.20	$ 6,985,037	$ 6,982,934	$ 6,981,790	$ 6,981,070	$ 6,980,575	$ 6,980,214	$ 6,979,939	$ 6,979,723	$ 6,979,548	$ 6,979,404	$ 6,979,283
0.30	$ 6,985,037	$ 6,982,705	$ 6,981,208	$ 6,980,166	$ 6,979,399	$ 6,978,810	$ 6,978,344	$ 6,977,966	$ 6,977,654	$ 6,977,391	$ 6,977,166
0.40	$ 6,985,037	$ 6,982,570	$ 6,980,832	$ 6,979,540	$ 6,978,543	$ 6,977,749	$ 6,977,103	$ 6,976,566	$ 6,976,114	$ 6,975,727	$ 6,975,392
0.50	$ 6,985,037	$ 6,982,482	$ 6,980,568	$ 6,979,081	$ 6,977,892	$ 6,976,919	$ 6,976,109	$ 6,975,424	$ 6,974,837	$ 6,974,328	$ 6,973,883
0.60	$ 6,985,037	$ 6,982,419	$ 6,980,373	$ 6,978,729	$ 6,977,380	$ 6,976,252	$ 6,975,296	$ 6,974,474	$ 6,973,761	$ 6,973,136	$ 6,972,584
0.70	$ 6,985,037	$ 6,982,372	$ 6,980,223	$ 6,978,451	$ 6,976,967	$ 6,975,704	$ 6,974,618	$ 6,973,672	$ 6,972,843	$ 6,972,108	$ 6,971,454
0.80	$ 6,985,037	$ 6,982,336	$ 6,980,103	$ 6,978,226	$ 6,976,627	$ 6,975,246	$ 6,974,044	$ 6,972,986	$ 6,972,049	$ 6,971,213	$ 6,970,462
0.90	$ 6,985,037	$ 6,982,307	$ 6,980,007	$ 6,978,041	$ 6,976,341	$ 6,974,858	$ 6,973,551	$ 6,972,392	$ 6,971,356	$ 6,970,425	$ 6,969,584
1.00	$ 6,985,037	$ 6,982,284	$ 6,979,926	$ 6,977,884	$ 6,976,099	$ 6,974,524	$ 6,973,124	$ 6,971,873	$ 6,970,747	$ 6,969,728	$ 6,968,802

Source: Villacis, 2011

Table N 4 Sensitivity Analysis: Distribution of Benefits (Pivotal Shift)

Elasticity of Supply	Elasticity of Demand											
	0.00		0.10		0.20		0.30		0.40		0.50	
	Consumers	Producers	Consumers	Producers	Consumers	Producers	Consumers	Producers	Consumers	Producers	Consumers	Producers
0.00	$0	$0	$0	$6,985,037	$0	$6,985,037	$0	$6,985,037	$0	$6,985,037	$0	$6,985,037
0.10	$13,970,074	($6,985,037)	$7,572,596	($589,182)	$5,195,411	$1,787,395	$3,954,358	$3,028,130	$3,191,956	$3,790,336	$2,676,042	$4,306,119
0.20	$13,970,074	($6,985,037)	$9,819,506	($2,836,571)	$7,571,712	($589,922)	$6,161,721	$819,349	$5,194,576	$1,785,999	$4,489,916	$2,490,299
0.30	$13,970,074	($6,985,037)	$10,897,807	($3,915,102)	$8,934,350	($1,953,141)	$7,570,828	($590,662)	$6,568,586	$410,813	$5,800,780	$1,178,031
0.40	$13,970,074	($6,985,037)	$11,531,084	($4,548,514)	$9,818,024	($2,837,192)	$8,548,523	($1,568,983)	$7,569,944	($591,401)	$6,792,512	$185,237
0.50	$13,970,074	($6,985,037)	$11,947,721	($4,965,240)	$10,437,552	($3,456,984)	$9,266,675	($2,287,594)	$8,332,204	($1,354,312)	$7,569,060	($592,141)
0.60	$13,970,074	($6,985,037)	$12,242,652	($5,260,233)	$10,895,984	($3,915,611)	$9,816,542	($2,837,813)	$8,931,893	($1,954,513)	$8,193,632	($1,217,380)
0.70	$13,970,074	($6,985,037)	$12,462,409	($5,480,037)	$11,248,930	($4,268,707)	$10,251,081	($3,272,630)	$9,416,020	($2,439,053)	$8,706,880	($1,731,176)
0.80	$13,970,074	($6,985,037)	$12,632,486	($5,650,150)	$11,529,044	($4,548,941)	$10,603,137	($3,624,910)	$9,815,060	($2,838,433)	$9,136,140	($2,160,893)
0.90	$13,970,074	($6,985,037)	$12,768,018	($5,785,711)	$11,756,764	($4,776,757)	$10,894,161	($3,916,120)	$10,149,636	($3,173,295)	$9,500,473	($2,525,616)
1.00	$13,970,074	($6,985,037)	$12,878,561	($5,896,277)	$11,945,533	($4,965,607)	$11,138,759	($4,160,875)	$10,434,205	($3,458,106)	$9,813,578	($2,839,054)

Source: Villacis, 2011

Elasticity of Supply	Elasticity of Demand									
	0.60		0.70		0.80		0.90		1.00	
	Consumers	Producers	Consumers	Producers	Consumers	Producers	Consumers	Producers	Consumers	Producers
0.00	$0	$6,985,037	$0	$6,985,037	$0	$6,985,037	$0	$6,985,037	$0	$6,985,037
0.10	$2,303,706	$4,678,359	$2,022,330	$4,959,662	$1,802,211	$5,179,725	$1,625,306	$5,356,583	$1,480,028	$5,501,824
0.20	$3,953,631	$3,026,308	$3,531,805	$3,447,918	$3,191,324	$3,788,224	$2,910,725	$4,068,679	$2,675,486	$4,303,797
0.30	$5,193,741	$1,784,603	$4,701,749	$2,276,217	$4,294,922	$2,682,731	$3,952,905	$3,024,486	$3,661,349	$3,315,817
0.40	$6,159,962	$817,141	$5,635,230	$1,341,336	$5,192,907	$1,783,207	$4,814,987	$2,160,740	$4,488,355	$2,487,037
0.50	$6,934,057	$42,052	$6,397,404	$578,020	$5,937,886	$1,036,951	$5,539,981	$1,434,347	$5,192,072	$1,781,811
0.60	$7,568,177	($592,881)	$7,031,492	($57,017)	$6,565,921	$407,840	$6,158,202	$814,934	$5,798,179	$1,174,405
0.70	$8,097,154	($1,122,536)	$7,567,293	($593,620)	$7,102,560	($129,717)	$6,691,635	$280,473	$6,325,682	$645,772
0.80	$8,545,147	($1,571,103)	$8,026,026	($1,053,040)	$7,566,409	($594,360)	$7,156,613	($185,401)	$6,788,950	$181,512
0.90	$8,929,436	($1,955,885)	$8,423,210	($1,450,818)	$7,971,345	($999,989)	$7,565,525	($595,100)	$7,199,050	($229,466)
1.00	$9,262,711	($2,289,586)	$8,770,456	($1,798,583)	$8,327,925	($1,357,178)	$7,927,939	($958,212)	$7,564,641	($595,840)

Source: Villacis, 2011

Appendix O: Processors Margins in the Dairy Industry of El Salvador

Table O 1 Processors Margins in the Dairy Industry of El Salvador.

	Year																	
Month	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Jan	38.25%	42.54%	32.11%	36.55%	28.68%	16.49%	15.66%	17.33%	15.63%	9.68%	12.12%	9.68%	3.03%	3.03%	25.00%	47.06%	19.05%	12.50%
Feb	44.93%	38.30%	35.98%	34.85%	26.35%	17.75%	7.53%	16.91%	12.12%	9.37%	32.14%	6.25%	3.03%	6.25%	17.65%	38.89%	25.00%	21.62%
Mar	42.86%	40.69%	34.30%	51.38%	17.75%	18.18%	2.39%	10.53%	19.35%	19.35%	23.33%	-2.86%	3.03%	9.68%	17.65%	31.58%	25.00%	38.89%
Apr	49.77%	44.44%	34.30%	32.00%	18.61%	17.33%	13.64%	14.50%	19.35%	9.68%	23.33%	9.68%	9.68%	17.24%	21.21%	38.89%	28.21%	47.06%
May	56.25%	47.06%	40.19%	40.69%	25.00%	19.05%	23.97%	17.31%	21.43%	21.43%	17.24%	13.33%	21.43%	21.43%	14.29%	40.63%	25.00%	47.06%
Jun	33.50%	40.19%	49.25%	45.74%	21.46%	36.55%	23.46%	20.48%	21.43%	20.00%	21.43%	17.24%	17.24%	21.43%	29.03%	25.00%	32.35%	66.67%
Jul	53.06%	43.54%	44.93%	44.63%	19.52%	21.95%	27.66%	25.52%	21.43%	20.00%	21.43%	17.24%	6.25%	21.43%	33.33%	28.57%	21.62%	47.06%
Aug	53.85%	42.18%	40.19%	48.94%	30.52%	18.58%	28.21%	28.69%	17.24%	13.33%	25.93%	17.24%	17.24%	21.43%	29.03%	56.25%	32.35%	61.29%
Sep	32.16%	40.85%	36.36%	47.06%	32.65%	27.95%	25.00%	31.91%	37.04%	13.33%	37.04%	13.33%	17.24%	21.43%	37.93%	42.86%	25.00%	42.86%
Oct	50.46%	33.33%	31.58%	45.83%	22.64%	27.91%	20.48%	26.46%	23.33%	20.00%	27.59%	13.33%	9.68%	25.00%	47.06%	35.14%	25.00%	42.86%
Nov	47.06%	28.76%	22.45%	31.58%	19.93%	26.44%	20.00%	19.49%	19.35%	20.00%	27.59%	9.68%	3.03%	21.21%	47.06%	31.58%	18.42%	38.89%
Dec	45.77%	40.24%	36.35%	41.13%	24.52%	21.00%	18.20%	20.17%	19.67%	15.66%	22.03%	10.27%	9.09%	16.02%	28.53%	37.65%	25.28%	39.62%
AVERAGE	45.66%	40.18%	36.50%	41.70%	23.97%	22.43%	18.85%	20.77%	20.61%	15.99%	24.27%	11.20%	10.00%	17.13%	28.98%	37.84%	25.19%	42.20%

Source: Villacis, 2011.