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FACING A FREE TRADE AGREEMENT: MONTE CARLO ANALYSIS OF SMALL DAIRY FARMS IN COSTA RICA

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ABSTRACT

Small dairy farms in Costa Rica are the most common; nonetheless milk and dairy industrialization is owned by few companies with large market power. The imminent entry to a free market, due to the Free Trade Agreement with United States, dairy imports are expected to increase in the upcoming years. This research analyzes through a Monte Carlo simulation, the probabilities of small and medium farmers to have higher internal return rates than their capital cost, variables considered for analysis were prices paid to farmers and price of urea, since feed costs are 51.82% of total production costs. Results show how when both, prices paid to farmers and prices of urea change according to their historical behavior and deviations, there is a 38.4% probability farmers would have losses according to an estimated 11.9% capital cost.

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INTRODUCTION

Milk production in Costa Rica has been increasing since 2010, nowadays, Costa Rica is the largest exporter of milk among Central America (Quirós, 2013). This has been partly achieved by the production of small farmers which are the predominant average size. Around 48% of total dairy farms in the country (INEC, 2014) are small which means that they own less than 15 cows (INEC, 2014). There are 12 974 dairy farms in the country which represents an approximate herd of 308 715 animals (INEC, 2014). There are also 14 974 dual purpose (milk and meat) farms with an approximate herd of 319 769 animals (INEC, 2014). Although there in an important dairy industry in Costa Rica, most (62%) production in the dairy industry is fluid milk. (Proleche, 2013). In terms of market size, import quantities have increased only by 4% butthe export quantity has increased in 12% on average during 2001-2012. In addition, the domestic consumption has also been increasing on average since 2000 (FAO, 2016).This means that small dairy farms play a crucial role not only in exports, but also in supplying the domestic market.

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Regarding inputs cost of production, the National Council of Production, states that around 51,82% of the total costs correspond to feed; 20,34% to labor cost; 5,97% to reproductive costs; 7,42% maintenances; 5,72% transport cost; 2,95% other services and the 5,78% remaining represents others costs as depreciation, financial expenses and others (Proleche, 2013). An important milestone occurred in2006, which was thatCentral America and Dominican Republic engaged in a Free Trade Agreement with United States, which is an important player regardingskimmed milk production and trade. The negotiation fixes20 years of tariff relief which states, at the beginning, 10 years of non-tariff relief, and then 10 years of linear tariff relief until reaching zero import tariffs (Sistema de Información sobre Comercio Exterior, 2016). Until 2015 fluid milk was protected in Costa Rica with 65% import tariff, however by the beginning of the 2016 the grace period end and the 10 years of linear tariff relief starts, by 2026, there would be no taxes on milk imports. In regard of the Costa Rican dairy industry despite the considerable number of farmers, there are few processors. Within the formal milk sector, market shares of the main companies are the following: Dos Pinos: 81.6%, Sigma: 9.8%, Monteverde: 3.7%, Coopeleche-Florida Lácteos: 2%, Coopebrisas: 1.2%, Coprolac: 1.2%, Los Alpes: 0.2%(Proleche, 2013). According

to the abovementioned situations, it is likely that Costa Rica, as a small developing economy, started to be a milk price taking country, as happens with meat prices (Rodriguez Lizano & Montero Vega, 2016), because of: (1) the big size and influence of the United States in fluid milk international market, (2) the small size of the Costa Rican economy, (3) the small size of farms in Costa Rica (4) the expected higher bargaining power of processors against farmers and (5) the ongoing process of import tariff relief of fluid milk from United States. In this sense it is fundamental to understand the situation of the small Costa Rican dairy farmers when facing different scenarios of feed costs, prices, transport costs and others variables.In order to findout these scenarios, a Monte Carlo method was applied to a cash flow of an average small dairy farm, by doing a sensitivity analysis of the feed prices and labor costs variables. Our goal is to visualize the effects of changes in feed costs and milk prices, given that small farmers are most likely going to face larger competition and their buyers(who are milk and dairy processors) would also face higher competition which often influences prices. In this particular research the main focus was on prices paid to small farmers and their situation rather than providing a deadweight gain or loss analysis.

Theoretical framework

Oligopoly in the Costa Rican milk industry occurs in the industrialization link of the supply chain, not in the primary sector of milk production since there are plenty of small, medium and large farmers who are solely producers. These sell raw milk to a fewer number of companies who produce most nationally consumed dairy products; however, bargaining power is most of the time tilted towards the industrializers, rather than farmers, because of the difference in size of these supply chain partners. Our hypothesis in this research states that with the implementation of the Free Trade Agreement and open market to more competition, oligopolistic would behave in the same way they do now; which is maximizing their profit margin. Therefore, with more competition, prices would no longer depend only on the oligopolists, but in a more competitive market. In this sense, rising prices would not be strategic, since there are going to be more imported products. Therefore, we assume, small and medium farmers, would be affected by lower farm prices in order for the oligopolists to maintain their profit margin and their prices at a competitive rate. Therefore, and since there is a predominance of small and medium farmers in Costa Rica, the following analysis focuses in a Monte Carlo simulation for risk analysis by estimating the most vulnerable variables and how changes on these would affect the average farmers cash flow in the attempt of providing academic assessment to the Costa Rican dairy sector prior to the tariff reduction stipulated in the Free Trade Agreement.

Prices in oligopoly

Since the milk industry in Costa Rica consists on a few enterprises with large markets shares, it is considered to be an oligopoly. Price fixation in oligopolies often consists on a price leader and a price follower; which derives in a sequential game for industries to decide for quantities, manipulate market shares first, and consequently, prices. Stackelber´s model analyzed quantity leadership in which the dominant firm in the market announces its products and then, all other companies follow depending on whatever suits them best according to their production possibilities. The follower would like to maximize its profits when MR=MC, however price is set according to total output produced; the follower´s output optimization is a function of the leaders' choice $y_2 = f_2(y_1)$; Stackelberg´s equilibrium stands in a total industry output of $y_1^* + y_2^* = \frac{3a}{4b}$

If the industry´s leader sets price instead of quantity, then the leader has to forecast how the follower will react. In this situation, the follower always set the same price as the leader. One important assumption is there is no product differentiation, firms are selling identical products and if either of the companies decide to lower prices, consumers would automatically prefer the producer with lower prices. Therefore, the follower would choose an output level in which price equals marginal cost. On the other hand, the leader would also set a price and output whose combination equals the point where marginal revenue equals marginal cost. The leader´s profit maximizing output is given by $y_1^* = \frac{a-c(b+1)}{2}$.

When there is also a leader and follower, but quantities are set simultaneously, firms have to forecast the other firm'soutput for them to make a decision on production quantity, and therefore, prices. Given each firm´s forecast, they set a profit maximizing output for themselves. According to Cournot´s equilibrium, the output choices satisfy the following conditions:

$y_1^* = f_1(y_2^*)$ ……..(1)

$y_2^* = f_2(y_1^*)$ ……...(2)

These outputs are the ones in which each firm is maximizing its profits, according to their estimation on their beliefs of what the other firms would set to produce. Prices can also be set simultaneously; this model is known as Bertrand´s competition. In this case, firms also have to forecast others firms' prices, *i.e.,* maximizing their profit given the choice made by the other firm. The model assumes prices are set above marginal cost, since firms would gain more by not producing if prices were set otherwise. In this case, lowering the prices by a small amount is also considered an as strategy to gain all consumers; if the other firms keep its price fixed, all the consumers will prefer to buy for the firm who reduced the price by a small amount. The rationale follows the only price each firms cannot expect to be undercut is a price equal to marginal cost; firms who are unable to collude, often result in prices that are much lower than prices achieved by other means.

Monte Carlo Simulation

Monte Carlo simulation methods have been widely used in different fields, however its core function is to model outcomes from random repetitions in order to estimate statistically the probability distribution of different outcomes of interest. Applications of Monte Carlo methods in agriculture and agriculture-related topics include a large spectrum of research topics since it is useful for estimating farming conditions in different areas such as a forecast on fruit harvest yield (Lopez, *et al.*, 2012), sustainable yields for fisheries (MacCall, 2009). Monte Carlo applications are as well useful regarding financial impacts and risk of agriculture, such are the cases of financial impacts of animal disease (Nampanya *et*

al., 2015), as well as in the impact on pay delay in agriculture programmes and how does this stabilize farm income (Antón, Kimura and Martini). In this case, we used the Monte Carlo method to simulate changes in cash flow indicators based on changes in the most significant variables which can be the most important according to their proportion in the global cost structure of milk production

Numerical implementation

Investment in equipment and other fixed assets for an average farm of about 15 Jersey cows was used as a case study; since a large proportion of farmers are small. Field data was collected from a farm located at San Vito de Coto Brus in the Southern region of Costa Rica. This farm already has 13 cows; in this sense cow´s investment on the first year only includes two cows. Table 1 shows the fixed assets considered for analysis.

Table 1. Investments* needed and considered for analysis in a small scale milk farm

Investments	Price*
Milking equipment	1125580
Car	2900000
Milking parlor	3000000
Fences	5054602
Food and water bowls	392562
Cows	422088

*Prices are given in Costa Rican colones.
Exchange rate: 558.59 colones/$ (September, 12, 2016)

In this case, there is an average production of about 12 kg per cow per day, having two milking times each 12 hours. As it was abovementioned, feed is the most important cost of milking production. In this case the farm owner manages to cover 7 out of12 kilograms of milk produced using the farm´s forage. This is how there are only 5 kilograms of milk left that must be covered using concentrated-based diet with a ratio 1:3, which means one kilogram of concentrated-based diet per 3 kilogram of milk produced. Having this in mind, just 1,66 kilograms of concentrated-based diet per cow per day have to be supplemented.

In addition to feed cost, others expenses were taken into account: water and electricity use, costs of insemination, veterinarian costs, assets maintenance, financial, transport and administration costs. Conversely non-cashcosts, such as depreciation, werealso considered. In this case income taxesdiffer from one year to another because of Costa Rican tax policy. During the first 3 years there was no utility and so the incometax was 0%, during the fourth year the utility level reach a level at which no income tax could be applied, however during the fifth and sixth years a 15% and 20% income tax was respectively used according to increasing returns on investment (Ministry of Financae of Costa Rica, 2016). Regarding herd size, the number of cattle in production stages increased along the 6-year period of this research. On the first year, there were 15 cows (13 already old + 2 as investment), however herd size increased from year 1 to year 6 in which there were 29 productive cows, due to artificial insemination. Table 2 shows the estimated increase in herd size.

Table 2. Annual number of productive cows

	Year					
	1	2	3	4	5	6
Total productive cows	15	15	19	24	29	29

Regarding capital cost, it was estimated by following equation and variable details are detailed in Table 3.

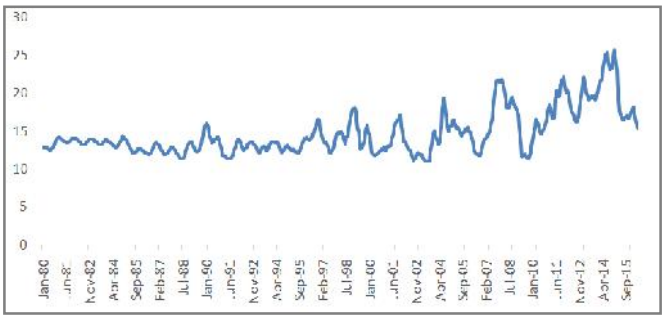
$$Capital\ Cost\ (K_e) = R_f + B\ R_m - R_f + R_p \quad \text{.....(3)}$$

Table 1. Variable detail for capital cost estimation

Variables	Variable Detail	Rate
R_f	30 years long term Costa Rican Euro bonus average yield	7,16%
R_m	Agriculture average yield	11,36%
R_p	Country risk	3%
B	Costa Rican annual milk price volatility	0,25
K_e	Capital Cost	11.19%

Sources:
R_f = Law n° 9070 proceso de emisión y colocación de títulos valores en el mercado internacional. Available at http://www.hacienda.go.cr/docs/5537ee50dc6fb_informe%20colocacion%20eurobonos%202015.pdf
B= price volatility of costa Rican milk prices paid to farmers (January 2006-january 2016)
R_m = according to costa Rican law for farmer loans law n° 8634: ley Sistema de Banca para el Desarrollo, it was estimated by tbp+4.5%; Farmers need 3,5% over this rate. TBP is 2015´s average available at:http://indicadoreseconomicos.bccr.fi.cr/indicadoreseconomicos/cuadros/frmvercatcuadro.aspx?idioma=1&codcuadro=%2017
Law n° 8634 available at: http://reventazon.meic.go.cr/informacion/legislacion/pyme/8634.pdf
R_p = country risk

Variables selected to perform the Monte Carlo simulation were prices of milk and cost of feed. In both cases, 1000 iterations were used and a normal distribution was assumed. In order to provide a more accurate estimator in probabilistic changes in both variables, international prices were used to estimate a coefficient of variation for each variable to include approximate and accurate fluctuations for both variables. Milk prices used in the cash flow are given in Costa Rican *colones*, however, to estimate the coefficient of variation in milk prices, information from United States market were used; monthly prices from 1980 to march 2016. Historical prices can be observed in Figure 1.

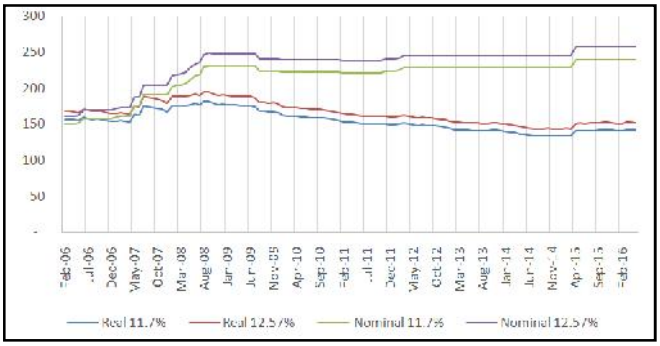


Source. Estimated with data from USDA, available at: https:// www.ams.usda.gov/market-news/dairy
*Standard deviation: 2.98, Coefficient of variation: 20.29%

Figure 1. Historical US milk prices* 1980-2016. $/cwt = 100 pounds

Costa Rican milk prices in *colones* can be observed in Figure 2. These have been steady, however the observed divergent prices since 2008 are the consequence of a monetary policy change in the estimation of local currencies with respect to international currencies. As a result, *colones* were appraised comparatively to previous years, nonetheless Figure 2 shows

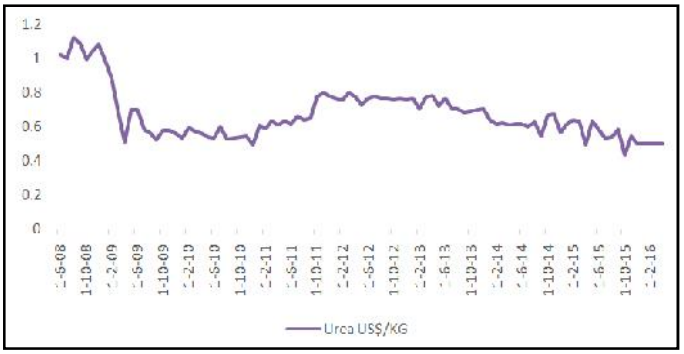
both, nominal and real prices for farmers. There are two milk-qualities in the country, dependant on the fat percentage).



Source. Proleche, 2016

Figure 1. Costa Rican milk prices 2006-2016. Colones/kg

In terms of cost of feed, urea is used internationally as an indicator since it is one of the most well-known supplements for cattle. Figure 3 shows prices of urea in the past years paid in the Costa Rican market. However, prices were dollarized it in order to obtain the coefficient of variation according to international prices.



Source. Proleche, 2016. *Mean price (2006-2016): $0.673/Kg; standard deviation: 0.1468; Coefficient of variation: 21.82%.

Figure 3. Dollarized urea prices*

RESULTS AND DISCUSSION

Free Trade Agreements are expected to reduce prices for consumers, since there is going to be a larger supply not only of milk but for all dairy products, since tariffs from United States milk imports are going to decrease until their total relief (0%)by the year of 2026. If the oligopolist who only buys from national farmers maintains its current average profit margins stable, we assume farmers would receive a decreasing price for raw milk and therefore, this research estimates the probability of small farmers to have profits when prices and feed costs vary, according to historic data. How would national small farmers face lower selling prices?

According to our results, with 15 productive cows, during the first three years of analysis, cash flow results were negative; when production increased, because of an increase in the number of productive cows, positive cash flows were obtained for the last three years. Therefore, it is mandatory to increase the average number of milking cows per farmer, for milk production to be profitable, *i.e.*, small farmers would need to increase their average herd size. The probability of small farmers whose herd increases from 15 to 29 in a 6-year span to have profitable businesses, is 38.4%; since we assumed an increase in productive cows, those who are already milk producers, would either need to increase their herd size so they can have profits or rather step out this business and sell their Cooperative-auctions to other larger-scale farmers. The probability distribution of Internal Return Rates (IRR) is shown in Figure 4. On the other, it is difficult for any small new farmer to engage in milk production, since according to our case study, there is a large probability that the first three years generate economic losses and only larger scale farmers with other sources of income could survive three years with negative data. If we added to this scenario quotas farmers have to pay in order to belong to a certain cooperative or association, cash flows would even be more pessimistic.

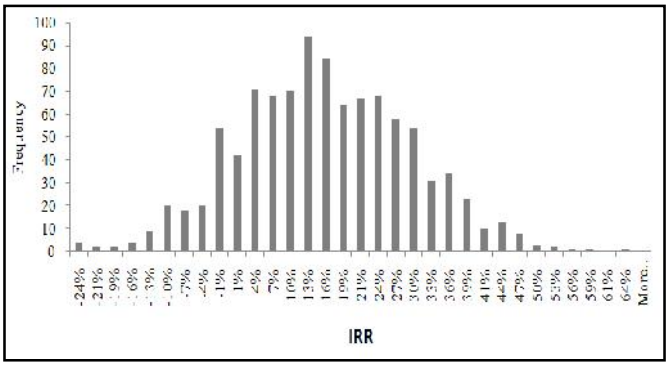


Figure 2. Probability distribution of Internal Return Rates for a small-milking farmer Monte Carlo Simulation

In this regard and given our assumptions, a change in the current average size of milk-herds is going to happen; which implies that the country´s structure would be expected to shift into larger-scale farmers, since small and medium farmers cannot profit from a 15 animal-sized farm.

Conclusion

This study has shown the probabilities of small milk farmers to have profits above an estimated 11.19% capital cost. Although, there is a large number of small farmers in Costa Rica, results show how the 15-cow average sized farm in the country should increase to at least double the number of milking cows for it to be profitable. Therefore, structural changes can be expected, since small farmers could no longer survive from milk production unless they have other income sources. Based on this results, further research on the effects of this FTA would be needed to estimate how it would affect poverty in rural regions, since although prices are expected to fall, small and medium farmers are also net food buyers. Nonetheless, farmers are usually only engaged in agriculture or agriculture-related activities and therefore they skills are targeted to farming or agriculture. Since a shift towards larger-sized farms is expected, what could happen with those farmers who do not have the possibilities of increasing their herd size? Although this research does not focus on general economic welfare analysis, further research on this regard could provide insight on which kind of policies can be used so that small farmers do not linger below the poverty line; since they are a large proportion of the Costa Rican farming industry.

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