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Article

# Competitiveness and comparative advantage in beef cattle production in the Sierra Norte of Puebla, Mexico

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**Abstract:**

Beef cattle production systems in Mexico are socially and economically important because they contribute to economic development by generating employment and income. Profitability and competitiveness in this subsector have been negatively affected by structural changes in government support as part of the economic integration of Mexico with the United States and Canada. An evaluation was done of the competitiveness and comparative advantages of beef cattle production systems in the Sierra Norte region of the state of Puebla, Mexico. Technical and productive information from 116 beef cattle production units were used in the policy analysis matrix method to identify benefits, restrictions and opportunities. Three production systems were identified: cow-calf (79 %), grower (13 %) and mixed (8 %). The private cost ratios (0.22 for cow-calf systems, 0.45 for grower systems, and 0.23 for mixed systems) indicated high competitiveness. The internal resources cost ratios (0.11 for cow-calf systems, 0.08 for grower systems, and 0.14 for mixed systems) implied they all have a comparative advantage. The effective protection quotients (0.55 for breeding systems, 0.16 for grower systems, and 0.64 for mixed systems) indicated that beef cattle production in this region lacks protection. The studied beef cattle production systems are profitable for the producers and for Mexico, but could clearly benefit from policy modifications aimed at generating positive incentives for production.

**Key words:** Cattle, Effective Protection, Private Profitability, Input Use.

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# Introduction

Livestock production in Mexico generates employment and income, which support national economic development, and provides food security, and household subsistence(1,2). In 2022, national beef production was 2,175,576 t, valued at 163,811,754 thousand Mexican pesos (MXP) (approximately USD 9.1 billion)(3). Since this production does not meet national beef demand, about 8.5 % of the beef consumed in Mexico is imported, mostly from the United States of America, Nicaragua, and Canada(4,5). This production deficit is the result of structural changes and adverse public policies applied to the livestock sector in the form of trade liberalization(6), privatization of government-owned companies, a reduction in credit, and elimination of subsidies(7). Over the last ten years, these policy changes have created disadvantages such as high input costs, livestock theft, higher transportation costs, and limited extension services(8). COVID-19 containment measures further aggravated these tendencies(9,10). Beef cattle production dynamics in these main importing countries directly impact the beef cattle subsector in Mexico(11), affecting producer competitiveness and productivity, and consumer purchasing power(12). Understanding the actual situation of producer competitiveness and their comparative advantages is essential to implementing policy instruments that help to minimize the impact of foreign competition on different types of producers in Mexico, especially small-scale producers(13).

In beef cattle production, competitiveness is defined as the capacity of this sector to face international competition, remain in international markets (mainly the United States), maintain production quality and efficiency, and generate greater profits from available resources. Other factors to consider include exchange rate fluctuations, marketing infrastructure availability and availability of relatively low-cost productive factors(14,15).

Various methods exist to measure competitiveness, but the policy analysis matrix (PAM) is a robust methodology that encompasses different approaches for measuring competitiveness and comparative advantage[16]. It is widely used and accepted[17-21]. This tool is fundamentally based on analysis of budgets at market prices and social prices (opportunity cost) to quantify the competitiveness and comparative advantages of production systems and the policy instruments that affect that competitiveness[13]. Research to date on competitiveness and comparative advantages in different economic sectors in Mexico is insufficient[22]. Existing studies using PAM to measure competitiveness in dual-purpose livestock[23] and in feedlot beef production systems[24] have shown negative competitiveness, good competitiveness or developing competitiveness.

Analyses need to be done of the trade policies that impact the competitiveness of regional beef production systems so as to identify efficient production and pricing patterns and therefore make relevant recommendations to policy makers. In the Sierra Norte region of the state of Puebla, Mexico, there is an apparent lack of protection for beef cattle producers, and their competitiveness and comparative advantages are negatively impacted by the costs of feed input, internal factors, and production system technical services. The present study objective was to use income, costs, tradable inputs prices, and internal factors to evaluate competitiveness and comparative advantages in beef cattle production systems in the Sierra Norte region of Puebla.

## Material and methods

The study was done among calf breeders and growers in six municipalities in the Sierra Norte region (20°34’ and 20°51’ N, 97°44’ and 98° 01’ W; 60 to 940 m asl). Regional climate is warm humid with 1,400 to 2,600 mm annual rainfall, and 22 to 25 °C average annual temperature[25,26]. Using National Livestock Registry information for the Sierra Norte of Puebla[27], a structured questionnaire was applied to a random sample of beef cattle production units; reliability was 95 % and accuracy was 9 %. The sample was distributed proportionally among the six selected municipalities which account for the largest livestock inventory in the region (45.5 %): 4.4 % of the sample was in Francisco Z. Mena; 6.6 % in Pantepec; 4.4 % in Venustiano Carranza; 6.2 % in Xicotepec de Juárez; 7.1 % in Jopala; and 9.3 % in Jalpan. Sample size was calculated with the formula:

$$n = \frac{(p)(q)(N)(z^2)}{E^2(N-1) + z^2(p)(q)}$$

Where N= total population of study area (4,453 production units), n= sample size, p= estimated positive variability (%): 50%, q= 100-p (negative variability), E= error or allowed estimation accuracy (9%), Z= confidence level, and Z from tables = 1.96
Inserting the appropriate values generated this calculation:

$$n = \frac{(0.50)(0.50)(4{,}453)(1.96^2)}{0.09^2(4{,}453-1)+1.96^2(0.50)(0.50)} = 116\ interviews$$

Final sample size was 120 producers. Questionnaire items addressed technical production data, income, costs and profits of each production system (Table 1). The data was organized into five categories: tradable inputs, production factors, materials, indirectly tradable inputs and expenses. All were expressed in their corresponding units to identify the technical coefficient matrices of the private budget. The private prices were then specified, which, based on the collected data, were the market prices received or paid by the producer to carry out the activity, both for inputs, and products and by-products. Within this budget, the loan for supplies represented the short-term refinancing loan producers can obtain to acquire inputs, raw materials and materials, pay wages and salaries, as well as other direct production expenses; with the approximate figures used by the Agricultural Trust Funds (Fideicomisos Instituidos Relacionados con la Agricultura - FIRA), the cumulative value of these concepts was MXP 280,000 (USD 15,556). The surveyed producers stated that banks offered an 18.23 % average rate. The costs of livestock depletion were calculated using the private prices considered in the internal factors, which include initial values, the use life of each system and annual recovery. The private budget was then generated by multiplying the amounts by the prices, and including income from total sales, total costs and producer profits.

Calculation of the social budget was done using the coefficients recorded initially and replacing the private prices with the economic or social efficiency prices of inputs, products and by-products. These are the prices that would exist in the absence of policy interventions and market distortions of factors and products[(28)]. For inputs, yellow corn was considered to be the main component of balanced feed, and the costs per dose for internal and external dewormers were estimated separately. For this purpose, the world-wide prices in the Agricultural Marketing Service[(29)] were used, adjusted for freight, insurance and tariff costs. Border (CIF - Cost, Insurance and Freight) prices were calculated to generate import parity prices. The FoB (Free on Board) prices for cattle, as well as the costs for bridge tolls, transport to distribution center and delivery were then added in. To this end, a balanced exchange rate was used calculated based on a 20.1 MXP/USD nominal exchange rate[(30)]; a rate adjustment was done for 2022 with 2018 as the base year, and referencing the producer and consumer price indexes for Mexico and the USA.

Long-term expected values were utilized to prevent data distortion due to global fluctuations and foreign policies. For the internal production factors, social value was estimated at a national level equivalent to its opportunity cost focused on the best alternative use, such as sheep farming. Unlike the private budget, short-term credit for supplies in the social budget considered the interest and inflation rates of Mexico (24 % and 7.82 %, respectively)[(31)], and the United States (4.75 % and 6.50 %, respectively)[(32)]; the resulting nominal parity interest rate was 14.36 %. The economic cost of water was quantified as the equivalent of payment of a fixed annual fee for livestock activities levied by the Agua de Puebla water company[(33)]. Finally, livestock import parity prices were calculated assuming entry at the Texas, USA, border[(34)]. This represented a producer's cost to import livestock to the location of consumption, that is, the social prices of this activity's products. After including the subsidies, taxes and exchange rate distortions that affect products and input prices, the quantities were multiplied by the prices to generate the social budget ([1]The complete calculations of the systems' private or social budget values are available).

The resulting data was processed with the PAM (Table 2). The values calculated from the previous budgets were replaced. First, private profitability (D) was calculated as the difference between total income (cattle sales and available stock in total herd: surplus heifers, culled calves and bulls) and costs (tradable and indirectly tradable inputs), and internal factors and other miscellaneous materials or expenses. Social profitability (H) was calculated as the difference between income and costs, but evaluated using social prices to analyze comparative advantage. Eliminating these effects allowed calculation of national beef cattle production profitability, which could be evaluated versus that of other countries to determine if it is competitive or not. Finally, the effects of policy (I, J, K and L) were estimated as the differences between the private and social evaluations for income, costs and profits. Under this premise, the differences between the private prices and social prices can be explained by the effects of policy distortions or imperfect markets.

**Table 2:** Policy Analysis Matrix

| | **Income** | **Costs** | | **Profits** |
|---|---|---|---|---|
| | | **Tradable Inputs** | **Internal Factors** | |
| Private prices | A | B | C | D[1] |
| Social prices | E | F | G | H[2] |
| Effects of differences and efficient policy | I[3] | J[4] | K[5] | L[6] |

[1] Private profits, D= A–B– C; [2] Social profits, H= E–F–G; [3] Product transfer, I= A– E; [4] Input transfer J= B–F; [5] Factor transfer, K= C–G; [6] Total transfer, L= D–H = I–J–K.
Source: Monke & Pearson[(21)].

Once private profitability was calculated, the private cost ratio (PCR) could be calculated. This is the quotient between the costs of production internal factors and the value added in private prices [PCR = C/(A-B)], which shows how much the system can afford to pay for internal factors and consequently if the producer is competitive.

Using each system's net social profitability, the internal resource cost ratio (RCR) was calculated by dividing the cost of internal factors valued at social prices (without subsidies) by the social value added [RCR = G/(E-F)]. This is the difference between a product's internationally-priced production value and the costs of tradable inputs at international prices. It indicates if the value of domestic resources is lower or higher than the value of earned or saved foreign exchange, and thus if there is any comparative advantage in beef cattle production.

Finally, an estimation of whether or not pricing policies encourage domestic beef cattle production was done by contrasting product market prices with product social prices (Pi/Pi* or A/E) using the Nominal Protection Coefficient for products (pNPC). The contrast of tradable inputs at private and social prices (Pj/Pj* or B/F) was done using the Nominal Protection Coefficient for inputs (iNPC). The Effective Protection Quotient (EPQ), another indicator of incentives, was defined as the ratio between value added at private prices and at social prices (i.e. without subsidies) [EPQ = (A-B)/(E-F)]. Finally, the Producer Support Estimate (PSE) was calculated as a proportion of total gross income to private prices (L/A) as a way of showing net policy transfer.

# Results

## Beef cattle production systems

Three beef cattle production systems were identified in the Sierra Norte. Most (79%) of the surveyed producers were engaged in cow-calf systems (CCS). This involves intermediate management with sufficient space for pasture rotation with an average stocking rate of 65 head. Minimal feed supplementation is used and calves are weaned at between 160 and 180 kg. A smaller proportion (13%) were using grower systems (GS). They purchase calves and finish them in intensive (6 mo), intermediate (12 mo) or slow (18 mo) systems. Finished animals are sold at 300 to 350 kg, and average general inventory was 33 head per producer. The smallest proportion (8%) were using a mixed system (MS) which combines the cow-calf and grower systems. This allows them to manage the complete lifecycle in the same production unit. It requires a good finishing plan, and can have an average of up to 90 head.

The dominant breeds in all three systems were zebu crosses with Swiss and Brahman, used in an attempt to maximize reproductive efficiency through continuous natural mating. Feed was based on grazing grass directly in pastures, with very few production units using supplementation with balanced feed and mineral salts. Consequently, most units reported low weight gain. Water was supplied from natural sources (rivers, streams and springs), was freely available to the animals and thus represented no cost to producers. Disease control depended largely on application of vaccines against rabies, brucellosis, blackleg, malignant edema, and clostridial infections. Parasites were controlled internally and externally through permanent and continuous doses of dewormers, and flea/tick baths. Producers incurred no electricity costs because they used grazing systems. Neither were there fuel costs because both weaned and grown cattle were sold at the ranch gate; purchasers directly assumed transportation costs. However, a transport cost for materials and inputs to the production unit was included.

## Profitability and competitiveness

The assessment of production process profitability identified the main production costs for the resources and factors used in each system (Table 3). Tradable inputs (feed, medicine) were the highest cost item per kilogram of meat in all three production systems (CCS, GS and MS), accounting for from 56 to 60 % of total costs. Internal factors such as labor represented 25 % in the CCS, 17% in the GS and 26 % in the MS. Labor included total daily wages per hectare for pasture maintenance (i.e., hoeing, herbicide and fertilizer application), as well as daily wages for herd care and management.

**Table 3:** Average production costs for inputs in beef cattle production in the Sierra Norte of Puebla, at private prices in constant values

| Concept | Private budget | | | | | |
|---|---|---|---|---|---|---|
| | CCS[§] | | GS | | MS | |
| | $ | (%) | $ | (%) | $ | (%) |
| Tradable inputs | 476,433.3 | 56.1 | 408,558.5 | 59.6 | 680,558.8 | 59.6 |
| Feed | 461,747.3 | 54.4 | 398,709.9 | 58.2 | 661,339.6 | 58.0 |
| Medicine | 14,686.0 | 1.7 | 9,848.6 | 1.4 | 19,219.2 | 1.7 |
| Internal factors | 213,044.0 | 25.1 | 116,722.0 | 17.0 | 299,444.0 | 26.2 |
| Labor | 162,000.0 | 19.1 | 91,200.0 | 13.3 | 248,400.0 | 21.8 |
| Credit | 51,044.0 | 6.0 | 25,522.0 | 3.7 | 51,044.0 | 4.5 |
| Water | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Misc. materials | 2,137.6 | 0.3 | 2,443.0 | 0.4 | 2,137.6 | 0.2 |
| Indirectly tradable inputs | 153,523.3 | 18.1 | 155,945.6 | 22.8 | 154,878.8 | 13.6 |
| Breeding stock | 93,869.3 | 11.1 | 123,407.4 | 18.0 | 70,368.8 | 6.2 |
| Installations | 59,653.9 | 7.0 | 32,538.2 | 4.7 | 84,510.0 | 7.4 |
| Administration and services | 5,700.0 | 0.7 | 3,900.0 | 0.6 | 6,200.0 | 0.5 |
| Total Income | 1,632,141.0 | | 831,600.0 | | 2,159,879.0 | |
| Total cost (excluding land) | 848,700.5 | 100.0 | 685,126.1 | 100.0 | 1,141,081.6 | 100.0 |
| Net profit (excluding land) | 783,440.5 | | 146,473.9 | | 1,018,797.4 | |

[§]CCS = Cow-calf system; GS = Grower system; MS = Mixed system.

Indirectly tradable inputs accounted for 18 % in the CCS, 23 % in the GS, and 14 % in the MS. This parameter considers depreciation values of breeding stock and calf values, as well as the recovery costs of equipment, assets and some implements not marketed internationally.

The highest effective income from cattle sales (47.9 %) was observed in the CCS, followed by the MS (47.1 %), and the GS (17.3 %) (Table 4). Both the CCS and MS were the most profitable systems because they sold breeding stock and controlled the complete weaning and/or finishing cycle, thus limiting and exploiting some input costs.

**Table 4:** Policy analysis matrix for beef cattle production systems in the Sierra Norte of Puebla

| | Income | Costs | | Profits (net) |
|---|---|---|---|---|
| | | Tradable inputs | Internal factors | |
| Cow-calf System | | | | |
| Private budget | 1,632,141 | 635,657 (38.9%) | 215,182 (13.2%) | 781,303 (47.9%) |
| Social budget | 2,426,316 | 604,038 (24.9%) | 207,789 (8.6%) | 1,614,489 (66.5%) |
| Divergences | (794,175) | 31,618 | 7,393 | (833,186) |
| Grower System | | | | |
| Private budget | 831,600 | 568,404 (68.4%) | 119,165 (14.3%) | 144,031 (17.3%) |
| Social budget | 2,035,388 | 747,034 (36.7%) | 137,268 (6.7%) | 1,151,086 (56.6%) |
| Divergences | (1,203,788) | (178,630) | (18,103) | (1,007,056) |
| Mixed System | | | | |
| Private budget | 2,159,879 | 841,638 (39.0%) | 301,582 (14.0%) | 1,016,660 (47.1%) |
| Social budget | 2,843,329 | 791,749 (27.8%) | 294,189 (10.3%) | 1,757,391 (61.8%) |
| Divergences | (683,450) | 49,889 | 7,393 | (740,731) |

In the CCS, total production costs (tradable inputs and internal factors) accounted for 52 % of the budget, resulting in a 48 % profit. In the MS, these costs accounted for 53 % of the budget, resulting in a 47 % profit. However, in the GS these costs were 82.7 %, with particularly high tradable inputs costs ($568,404), resulting in less than half the profits of the other systems (17.3 %). In the private budgets, the profitability indicators showed that all three systems were profitable due mainly to the use of up-to-date technology, current market prices, and transfers or taxes generated by economic policy measures.

The prices of yellow corn and medicine (triple bacterin, amitraz, and ivermectin) were included in the social budget analysis. The best social budget among the three systems was for the CCS, which had an almost 67 % profit and just 25 % tradable inputs costs. In the GS, the tradable inputs costs (36.7 %) kept profits below 57 %, even considering price changes due to exchange rate adjustments.

The above shows that the GS exhibited negative transfers of both products (I) and inputs (J). This was due to two main distorting policies that cause divergences between observed prices and world prices. The first are taxes, subsidies and commercial policies applied to breeding or growth calves in Mexico, which affect private profitability. The second refers to the social foreign exchange rate policy which differed from the observed rate such that it was undervalued by -0.08 %, resulting in a real exchange rate of 18.57 MXP/USD. This constitutes an implicit support for producers since it generates an indirect saving on inputs.

In summary, the sum of the negative incomes for the inputs (J) and internal factors (k) divergences reflect a positive net transfer (L) to the system.

This is confirmed by the PCR and RCR, as well as the EPQs. With values near zero, the PCRs of all three systems confirm that the surveyed producers were competitive (Table 5), mainly because sales of calves and breeding stock allowed them to pay the value of the production factors and still generate a profit.

**Table 5:** Profitability and protection indicators for beef cattle production systems in the Sierra Norte of Puebla

| **Concept** | **Production system** | | |
|---|---|---|---|
| | **Cow-calf** | **Grower** | **Mixed** |
| Private Cost Ratio | 0.22 | 0.45 | 0.23 |
| Internal Resources Cost Ratio | 0.11 | 0.11 | 0.14 |
| Producer Support Estimate | (0.51) | (1.21) | (0.34) |
| Product Nominal Protection Coefficient | 0.67 | 0.41 | 0.76 |
| Inputs Nominal Protection Coefficient | 1.05 | 0.76 | 1.06 |
| Effective Protection Quotient | 0.55 | 0.20 | 0.64 |

Given that their PCR was the lowest (0.22), the CCS were the most competitive of the three studied systems. The higher PCR (0.45) for the GS showed that their profits were negatively affected by the extended growth time in the corral.

Both the CCS and GS had a low RCR (0.11), highlighting their social profitability. Their low RCR indicates they have comparative advantages, and that beef cattle production can be profitable in Mexico if resources are used efficiently; in other words, the value of the internal resources required for production was lower than the savings in foreign currency.

All three system types had EPQ values lower than 1.0, confirming the disincentives originating in policy interventions and the consequent lack of protection. The negative PSE values in all three system types represent their high private costs versus social costs due to prevailing economic policies. For example, gross income taxes imposed on GS producers were 121 %, an artifact of policy distortions and market imperfections in internal production factors.

Overall, the pNPC values were less than one, confirming a lack of protection for beef cattle production in the study area and suggesting that current policies inhibit national production. For the iNPC, both CCS and MS had values greater than one, indicating protection of negative price policies; that is, they benefit from an indirect subsidy not reflected in the iNPC for the GS.

# Discussion

## Beef cattle production systems

Beef cattle production systems in the Sierra Norte region of Puebla are similar to others reported in Mexico. In one study, full cycle and cow-calf-to-weaning systems in Tizimín municipality in the state of Yucatan[35] were reported to use zebu breeds and crosses with European breeds, extensive grazing and corral feeding, although the systems were stratified based on number of head and stocking rate. Another study, of small and medium production units in the southern portion of the State of Mexico[36], identified three systems based on livestock production surface; all the producers used zebu, Brahman and Swiss breeds and crosses between them, and, generally, grazing with complementary supplementation.

## Profitability and competitiveness

The present results for the percentage participation of costs is similar to that reported in a study of corral-grown cattle production in Tejupilco and Amatepec, in the State of Mexico[24]. In this study, costs were primarily (80 %) tradable inputs, followed by internal factors (10 %) and the remaining production costs (10 %). Feed, health and fuel costs represented more than 86% of variable costs in a study of dual-purpose cattle production systems in Jamapa municipality, in the state of Veracruz[37]. Labor costs accounted for up to 60 % of fixed costs, meaning that these factors generated the greatest economic and productive impact. The CCS had the highest effective income compared to MS and GS. This is supported by a study on calf grazing in the state of Sonora[38] which observes that traditional extensive cow-calf systems better utilize natural land conditions as long as they are extensive enough. They allow for adequate management because calves are left in pastures after weaning where they can gain various kilograms per day.

Indeed, as supported in the present results, grazing is an effective way of controlling total costs. This is further supported by a study of the beef production model in Chile, in which estimates showed that in mixed systems grazing is an effective and economic source of feed[39]. In these systems, supplementation is only needed in months of low pasture biomass

production or during the finishing stage to ensure efficient weight gain and maintain producer profitability.
Among the three systems studied here, the GS had the lowest percentage of effective income. This is similar to a report on intensive, semi-intensive, and extensive cattle grower systems in Gowa, Malaysia(19). In these systems, total income from cattle sales varied according to sale price, and price was influenced by growth duration. Income was consequently highest for producers using a slow growth strategy (48 %), compared to those using intermediate (33 %) and intensive (18 %) strategies; suggesting that the strategy used may affect profits.

The profitability results for the three systems studied here are similar to those reported for three types of corral grower systems in the southern portion of the State of Mexico(28). As observed in the present results, each producer type used efficient input management to generate additional income for each peso invested, meaning all production factors contributed to creating added value.

The present social budget results are comparable to those in a study of grower systems in Bali, Indonesia(18) in which profits were generated at both the private and social levels. However, non-tradable input costs were much higher in this study due to producer dependence on internal production inputs.

The negative transfers observed here in both the products (I) and inputs (J) affecting private profitability were probably the result of changes in federal agricultural policies in Mexico after ratification of the North America Free Trade Agreement (NAFTA) in 1993. Tariffs were reduced, and support and subsidies for agricultural activity were progressively withdrawn. This treaty has prevented strengthening of beef cattle production in Mexico through public policy(5).

Although all three studied systems were deemed economically efficient, their competitiveness results were lower than the 0.51 to 0.52 PCR reported for three types of corral cattle systems in Tejupilco(24).

The comparative advantages for the three studied systems were similar to the 0.31 reported in a study of ruminant systems in Malaysia(20); as observed in the present results, these advantages were created through efficient use of domestic inputs and resources in production, and the saving or earning of foreign currency.

The present EPQs results were similar to a study using PAM(40) to identify federal livestock policy as an example of weak governance, since, beginning in the 1980s, the Mexican government has eliminated or reduced support for livestock and agricultural production. This contrasts with the 1.71 EPQ reported for grower systems in Gowa[19], a manifestation of the impact of government policies supporting domestic productive activities. In this study, the ESP was positive (0.15) indicating that government policies allowed the studied grower systems to incur lower private costs than social costs.

Overall, the present PAM results confirmed that the studied CCS, GS and MS are efficient and profitable for producers since they have a comparative advantage and are competitive. However, despite their efficiency, government policy exploits their comparative advantage to keep prices low, meaning they are relatively unprotected. This lack of protection may be due mainly to an absence of public policy support for the livestock subsector aimed at strengthening national production. The absence of support allows foreign products to at least partially substitute domestic production, negatively affecting producers in Mexico.

## Conclusions and implications

Application of the policy analysis matrix to beef cattle production systems in the Sierra Norte region of Puebla identified the cow-calf systems as having the best private profitability, the grower systems as having the highest comparative advantage and the cow-calf systems as the most competitive. In all three systems, tradable inputs (food and medicine) accounted for most of the costs in the production cost structure per kilogram of meat. The ratio between production value at domestic market prices and international prices showed that pricing policies discourage domestic production. Through changes in policy that distort efficiency, as well as direct subsidies, domestic production systems could improve their market participation in private and social terms, with a consequent increase in income.

**Table 1:** Technical and production data

| Variables | Measurement unit | Definition | Interpretation | Formula |
|---|---|---|---|---|
| Tradable inputs | pesos/ton<br>pesos/treatment | Inputs required for cattle production, available domestically and internationally | These coefficients show the amounts used and prices paid by the producer in the regional market for inputs, products and byproducts, | (+) feed<br>(+) medicine |
| Internal factors | pesos/work day<br>pesos<br>pesos/m$^3$<br>pesos/equipment | Production factors without an international price (land, labor, capital) | | (+) labor<br>(+) credit<br>(+) water<br>(+) misc. materials |
| Indirectly tradable inputs | pesos/head<br>pesos/infrastructure | Inputs untradable internationally (e.g. implements and basic equipment) | | (+) breed stock<br>(+) installations |
| Administration and services | pesos/hour<br>pesos/service<br>pesos/ha | Factors with no international price, needed to manage and support production | | (+) containers<br>(+) veterinarians<br>(+) hauling<br>(+) taxes |
| Total income | pesos | Income from sale of breeding stock, grown calves (slow, intermediate or intensive), surplus or culled animals | Financial resources received by producers from cattle sales | (+) sale weaned calves<br>(+) sale grown calves<br>(+) other sales |
| Total cost | | Total value paid for goods and services required for production | Sum of all input and product costs for production | (+) tradable inputs<br>(+) internal factors<br>(+) indirectly tradable inputs<br>(+) administration and services |
| Profit | | Total difference between income and production cots | Financial profit or earnings in beef cattle production units | (+) total income<br>(-) total cost |

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