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THE BOLIVIAN BEEF CATTLE INDUSTRY: EFFECTS OF TRANSPORTATION PROJECTS UPON PLANT LOCATION AND PRODUCT FLOWS IN BENI

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The Bolivian beef cattle industry: Effects of transportation projects upon plant location and product flows in Beni

by

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GLOSSARY OF ABBREVIATIONS

BAB	Banco Agricola de Bolivia (Bolivian Agricultural Bank)
BECASA	Beneficiadora de Carnes S.A. (Meat Processing Company)
CBF	Corporacion Boliviana de Fomento (Bolivian Development Corporation)
CNC	Comite Nacional de Carnes (National Meats Committee)
CNRA	Conseyo Nacional de Reforma Agraria (National Agrarian Reform Council)
CODEBENI	Corporacion de Desarrollo del Beni (Beni Development Corporation)
COMIBOL	Corporacion Minera de Boliva (Bolivian Mining Corporation)
CORDECRUZ	Corporacion de Desarrollo de Santa Cruz (Santa Cruz Development Corporation)
ENFE	Empresa Nacional de Ferrocarriles (National Railway Company)
FAO	Food and Agriculture Organization of the United Nations
FAO-WB	Food and Agriculture Organization of the United Nations and World Bank
FEGABENI	Federacion de Ganaderos del Beni (Beni Cattlemen Federation)
FEGASACRUZ	Federacion de Ganaderos de Santa Cruz (Santa Cruz Cattlemen Federation)
HV	Hunting Technical Services, Ltd. and Manuel Vivado P. y Asociados - Consultoria Agropecuaria
IBRD	International Bank for Reconstruction and Development
JUNAC	Junta del Acuerdo de Cartagena (Board of the Cartagena Agreement - Andean Pact)
LAB	Lloyd Aereo Boliviano (Bolivian Airline Company)

MACA	Ministerio de Asuntos Campesinos y Agricultura (Ministry of Peasant Affairs and Agriculture)
MICT	Ministerio de Industria, Comercio y Turismo (Ministry of Industry, Commerce and Tourism)
MTCAC	Ministerio de Transportes, Comunicaciones y Aeronautica Civil (Ministry of Transportation, Communications, and Civil Aeronautics)
OEA	Organizacion de Estados Americanos (Organization of American States)
SNC	Servicio Nacional de Caminos (National Highway Service)
USAID	United States Agency for International Development
WB	World Bank

CHAPTER I. INTRODUCTION

Attempting to diversify the country's export mix, Bolivian policymakers have assigned a key role to the agricultural sector, and especially to the beef-cattle industry. The fact is that Bolivia has a significant beef production potential in her tropical lowlands, although the industry is still in a primitive state.

Various observers have presented to the Bolivian government a series of recommendations to develop the cattle-beef industry. Among these recommendations, the improvement of slaughterhouse facilities is considered essential. Experts agree that only with adequate slaughterhouses will the country be able to satisfy sanitary requirements of beef importing countries. As a consequence, several patterns have been suggested for the location of new or improved slaughter plants.

In the course of the 1980s, Bolivia is expected to achieve a long sought dream, namely, the integration of her territory. This will be possible when the transportation linkages currently under construction are completed. These linkages will connect the tropical hinterland with the highlands and valleys of the country.

The department of Beni, which hosts the bulk of the country's cattle population, and where the growth potential for the industry is greatest, is going to be the most affected by the new transportation linkages. What will happen then to optimal slaughterhouse location patterns and factor-product flows in Beni as the transportation projects are completed? The present dissertation is devoted to answering this question. In so doing, this study intends to provide an analytical technique which may be useful to policymakers and private entities who are involved in slaughterhouse development.

Chapters II, III, and IV contain background information needed to understand the problem at hand, that is, the basic features of the Bolivian economy and society, her cattle industry, and her transportation system. Chapters V and VI present the problem situation and the analytical technique to be used. Chapter VII presents the principal statistical information employed in the analysis. Chapter VIII illustrates the findings and Chapter IX offers the main conclusions of the study.

CHAPTER II. FEATURES OF THE BOLIVIAN ECONOMY AND SOCIETY

Introduction

Although resting upon ancient cultural foundations, Bolivia is a young nation that is still developing her own identity and subduing her territory. Unlike other nations in the Americas where the indigenous population and culture were shattered by the European invaders, in Bolivia the pre-Columbian people and cultures were able to resist the hardships of colonial rule and become the nucleus of the new republic.

Table 1 contains several of the more important socioeconomic indicators of Bolivia. Such figures permit one to appreciate the magnitude of the country's current state of underdevelopment. It can be observed that the Bolivian population is relatively small in comparison to land area, largely rural, indigenous, young and illiterate. Income per capita and life expectancy are low. Population is growing rather rapidly, and the income distribution is quite skewed. By world standards the Bolivian population is poor, inadequately fed, illiterate and unintegrated.

The geographical factor

Bolivia is the fifth largest country in South America, having approximately 1,100,000 square kilometers, or roughly the combined areas of the states of Texas and California. The Bolivian territory is characterized by a striking geographical diversity, and can be partitioned into three markedly different regions. These regions

Table 1. Bolivia: statistical profile[a]

Land area (Km^2)	1,098,581.
Population (mid-1980)	5,025,000.
Urban population (1977)	39.6%
Indigenous population	50-67%
Annual population growth (ave. 1970-1977)	2.8%
Population under 20 years of age	50-56%
Birth rate per 1000 inhabitants (1975)	46.6
Mortality rate per 1000 inhabitants (1975)	18
Infant mortality rate per 1000 births (1975)	175
Years of life expectancy at birth (1975)	48.2
Share of literate population (1976)	32%
Average calorie intake (1970)	1890
GNP in millions of 1976 dollars (1977)	2,320.6
GNP per capita in 1976 dollars (1977)	484.7
Rate of growth of GDP (ave. 1960-1977)	5.7%
Rate of growth of GDP per capita (ave. 1960-1977)	3.5%
Income distribution:	
Percentile of recipients	Income share (%)
Below 20%	3.5
21% - 40%	8
41% - 60%	12
61% - 80%	15.5
81% - 95%	25.3
96% - 100%	35.7
Gini ratio	.53

[a]Sources: James W. Howe, et al. 1975; Inter-American Development Bank, 1977, p. 160; Boyd E. Wennergren and Morris D. Whittaker, 1975, p. 22-3.

are the highlands, the valleys and yungas, and the lowlands, which are shown in Figure 1.

Highlands The highlands region comprises areas which are 10,000 feet above sea level or more. Such areas include the Altiplano, an extensive plateau enclosed between two branches of the Andean mountain range. Lake Titicaca, El Alto Airport, and the city of La Paz are all in this plateau, and are the highest navigable lake, international airport, and national capital in the world, respectively. These features have largely contributed to shape the country's international image.

Very low and variable temperatures, high altitudes, and rough geographical conditions make this region relatively unattractive for agricultural production activities. The principal economic activity is centered around the mining industry, which generates the bulk of the country's exports.

Valleys and Yungas The Bolivian valleys and yungas are formed by the eastern slopes of the Andes. The yungas are characterized by steep tropical and subtropical river valleys. The region has heavy rainfall and hosts cold, dry, and high mountain valleys, varying in altitude between 3,000 and 10,000 feet above sea level. The principal products of the region are wheat, milk, corn, cotton, and oilseed.

Lowlands The lowlands comprise the areas in the north and eastern parts of the country. Three principal subregions can be distinguished:

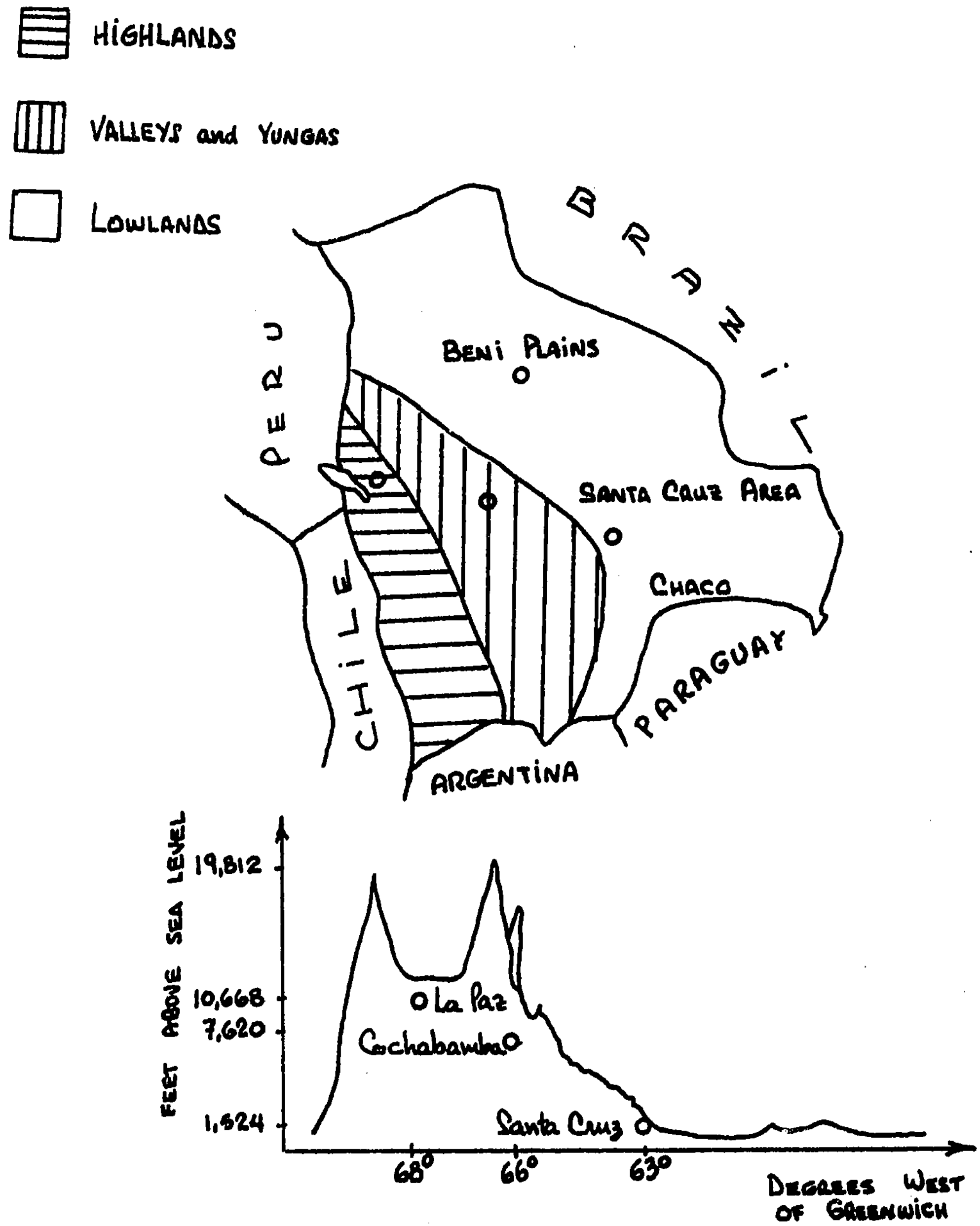


Figure 1. Geographical regions of Bolivia (Wennergren and Whitaker, 1975, p. 20)

Beni plains These plains comprise the northeastern portion of Bolivia. Their altitude varies from 500 to 1,500 feet above sea level. Rainfall is abundant, and because these areas are mostly flat, seasonal flooding is a common occurrence. The climate is hot and humid, the main activities being related to agriculture and livestock. The principal products of the region are cattle, Brazil nuts, rubber, and hardwoods.

Santa Cruz This area is typified by subtropical climate, with an average annual temperature of 75° F. Extensive plains, of which approximately one-half are covered with woodland, dominate the landscape. Altitudes vary from 1,000 to 1,500 feet above sea level. The main agricultural products are cattle, rice, woods, sugar, cotton, and casaba,

Chaco Finally, the Chaco area is located in the southern part of the Bolivian lowlands. Altitudes vary from 1,500 to 2,300 feet above sea level. It is characterized by gentle slopes with occasionally extensive valleys. Economic activities involve cattle growing and agriculture.

Location and communications

Bolivia is located near the heart of South America and is surrounded by five countries (Peru, Brazil, Paraguay, Argentina, and Chile). Because of this situation, Bolivia has been referred to as "country of contacts". Moreover, the leading geopoliticians of the nation derive her reason to exist in fulfilling her role as "buffer state" in a volatile region. However, her peculiar location, size, and physical features have historically prevented an effective control of her territory.

The Latin American nations inherited an underdeveloped transportation system from the colonial period. The Spanish rulers did not seek to integrate the economies of their colonies. This situation partly explains why the development of most countries in Latin America has been concentrated in certain urban islands close to the coast.

Another factor that has negatively contributed to the development of linkages among the Latin American nations has been the fear of national governments that transport improvements can bring invading armies as well as trade. In this respect, loosely defined borders and conflicting national interests have led to numerous confrontations and frontier disputes between Latin American nations. Bolivia had to engage in the course of her republican life in several border conflicts, as a consequence of which she lost roughly one-half of her original territory, as is shown in Figure 2.

Bolivia's isolation was reinforced by the 19th century loss of her entire sea coast in a war against Chilean-British interests. After such an unfortunate event, the country was left without a sovereign outlet to the Pacific Ocean, which is considered to be the principal continental transport medium. Since then, the country's exports have had to be shipped through Chilean and Peruvian seaports.

In relation to waterway communications with the Atlantic Ocean, Bolivia's direct access to the Amazon river is interrupted by the hazardous Madeira-Mamore rapids and falls. Access to the Paraguay

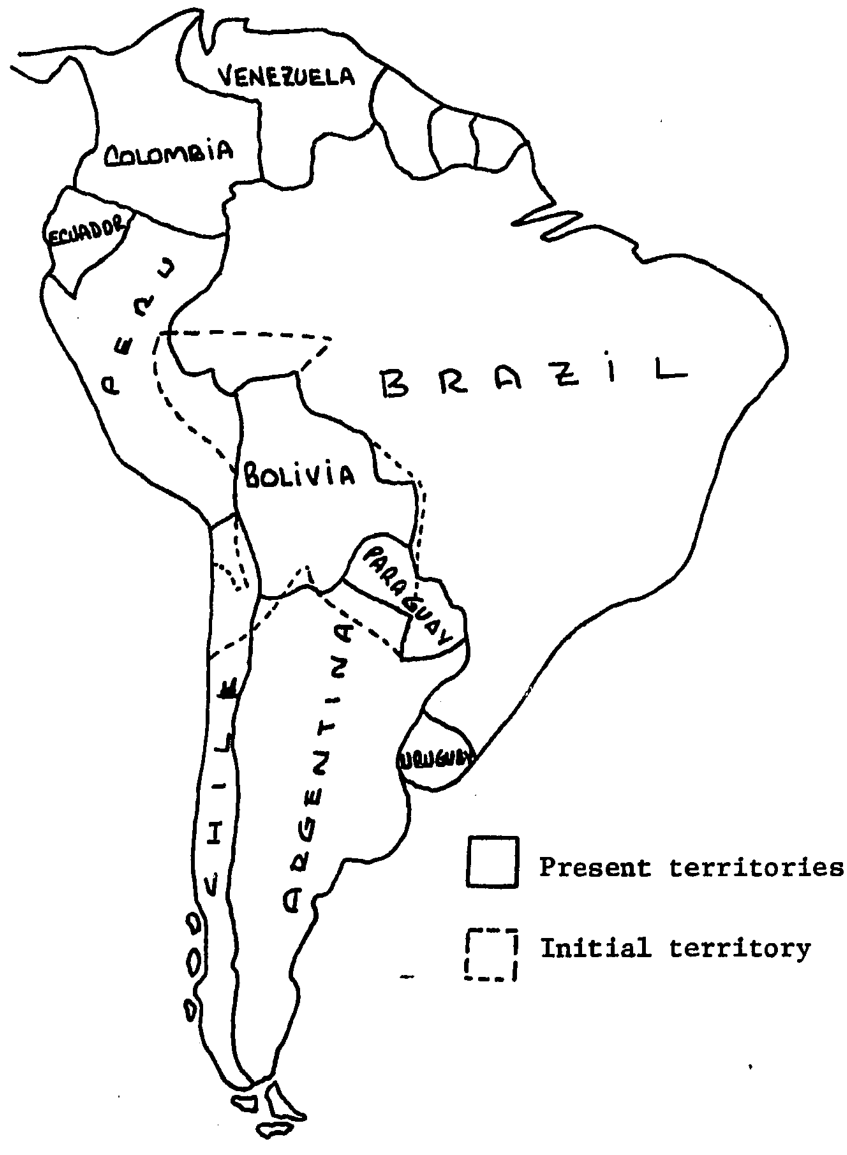


Figure 2. Location of the Bolivian territory (J. Valerie Fifer, 1972, p. xiiii)

river, which channels into the La Plata river, is impeded by shallows, seasonal flooding and swamps (Fifer, 1972, p. 19).

According to Brown (1966, p. 95), Latin America is almost completely dependent upon ocean transportation for both intraregional and extraregional trade. Consequently, Bolivia as a landlocked country must depend on her coastal neighbors for ports. Not possessing a sea coast, the country has remained isolated from the major trade and migratory movements taking place elsewhere in Latin America. As Fifer (1972, p. 3) mentions:

> "From the outset, international and external communications formed one of the weakest aspects of Bolivia's political and economic geography, and the greatest single obstacle to further development."

Additional reasons that have limited investments in transportation infrastructure in Latin America have been the lack of capital, the topographical barriers, and the concentration of population close to the coast. These conditions have encouraged, however, the development of air transportation. In South America, air traffic in proportionately more important than for the world as a whole (Brown, 1966, p. 207).

Bolivian socioeconomic development has been historically linked to the country's mining industry, which is concentrated in the highlands. As a consequence, until 1954 there existed no transportation infrastructure connecting the lowlands with the rest of the country. Even today most of the tropical hinterland is linked to the highlands mainly by air transportation. Bolivian planners have recognized the benefits to be obtained from improved transportation connections, and have promoted various major linkages so as to integrate the lowlands to the rest of the nation. In the international front, efforts have been made to obtain a seaport in the Pacific Ocean and gain access to the Atlantic Ocean via the Paraguay river. A highway is being constructed between La Paz and Ilo (Peru), which will put La Paz at seven hours motor drive from the ocean.

Population characteristics

The Bolivian population is heterogeneous, with marked economic, cultural and racial differences. These features together with the country's small size and uneven population distribution have negatively contributed to socioeconomic development. As Table 2 shows, population densities of the principal geographical regions vary markedly. The bulk of the population is concentrated in the highlands, yungas and valleys, while the lowlands are relatively underpopulated.

Table 2. Regional distribution and density of the Bolivian population (1972)[a]

Region	Share of population	Land area Km^2	Density pop./Km^2
Highlands	44%	182,048	12.61
Yungas and valleys	40%	189,225	10.99
Lowlands	16%	723,560	1.11

[a]Source: Wennergren and Whittaker, 1975, p. 168.

The uneven population distribution and underpopulation of the lowlands cause tropical land settlement to be an essential factor in achieving increased agricultural production and reduce the population pressure on the land in the highlands and valleys. Properly undertaken, colonization of the Bolivian lowlands could prevent the emigration of thousands of individuals, provide an outlet for surplus population in other regions of the country, encourage the return of emigrated nationals, and attract foreign immigrants.

In spite of the public willingness to settle the lowlands, the steps and measures taken so far have been mostly experimental. The lack of resources and the complexity of the task have generally resulted in poorly planned and inadequately implemented colonization projects.

Economic conditions

Bolivia's economy has been historically weakened by a condition of dependence on foreign powers and her reliance on raw material exports. In colonial times, Spain established a relationship of complete dominance with her American colonies. The Spanish colonies in the New World became raw material exporters and importers of consumer goods and equipment, all of which were channeled through the metropolis, Spain.

The Spanish rulers were mainly interested in the exploitation of silver and gold and in securing a submissive market for the products they sold. Little was done to strengthen or integrate the economies of the colonies. What was to be the Bolivian nation was endowed with poor internal transportation infrastructure, as this was laid to serve the export oriented mining industry. Furthermore, the accentuated priority given to mining activities led to the neglect of other productive sectors such as agriculture and manufacturers.

Gonzales Ruiz indicates that the Spaniards discouraged the growth of agriculture and other industries in their colonies to inhibit production of commodities being marketed by the metropolis, such as textiles and wines (Gonzales Ruiz, 1956, p. 27). The only agricultural activities that were allowed to develop were those in which Spain did not enjoy a competitive position, such as sugar, coffee, hides, cacao, cotton, and cereals.

With the decline of the Spanish empire, other world powers such as Great Britain and France eagerly sought to share in the spoilage of the American colonies. Great Gritain was able to secure, after the lengthy and bloody independence wars, unrivaled predominance over the former Spanish colonies.

As Klein (1969, p. 2) observes, by 1825, the richness and glory of Potosi were gone, and the Bolivian nation was born with a weak economic base. During the first fifty years of republican life (1825-1875), Bolivia's economy depended on silver exports. However, in the last quarter of the 19th century, silver prices fell as mine fields of the metal were reaching exhaustion. As a consequence, silver production plummeted.

The fall of silver coincided with the rise of the cinchona bark, as the prices for this vegetal product reached high levels by 1880. Economic prosperity accompanied the ten years in which cinchona bark was exported. Such prosperity ended almost as rapidly as it had begun, as Far East producing countries entered into the world market.

Rubber production followed the fall in cinchona bark activities. For a period of twenty years, and up to 1910, Bolivia enjoyed what is referred to as the rubber boom. As had happened with the cinchona bark, Bolivian rubber production was displaced by better quality, more efficient Asian producing countries.

After the rubber boom, tin production began to gain importance as prices for the metal increased and the Bolivian highlands were connected with the Pacific Ocean by railroad. During the present century, the country has relied mostly on tin exports to a few countries to earn her foreign exchange. In the 1929-1933 period, the United Kingdom purchased more than two-thirds of the country's exports. In the 1934-1940 period, the United Kingdom, the United States, and Belgium accounted for more than 90 percent of Bolivia's exports (Gonzales Ruiz, 1956, p. 34). The United States built a tin smelting plant in Texas at the start of World War II, when the Germans blockaded the Atlantic Ocean. As a consequence, in the period 1941-1959, the United States purchased more than 60 percent of the Bolivian exports. In this same period, the United Kingdom and the United States received about 96 percent of all Bolivian exports.

In the period 1970-1977, as Table 3 reveals, the United States and Canada were Bolivia's principal trading partners. Among the Latin American nations, Brazil and Argentina accounted for the largest trading volumes with Bolivia.

Table 3. Bolivia: absolute value of trade for the period 1970-1977 ($ U.S. million)[a]

Trading partner	Exports 1970	Exports 1975	Exports 1977	Imports 1970	Imports 1975	Imports 1977
World	228[b]	519	538	159	558	831
U.S.	201	302	320	123	340	499
Canada	74	162	150	49	139	236
Japan	21	18	17	26	88	104
Germany	6	18	26	20	43	73
U.K.	87	56	59	8	14	23
Argentina	11	128	133	16	80	111
Brazil	1	18	23	3	80	159
Chile	2	6	10	2	11	12
Colombia	0	1	5	0	10	10
Peru	6	7	27	2	9	12

[a]Source: Wilkie, James W., 1980, p. 434.

[b]Note: Figures have been rounded to nearest integer.

Table 4 shows the importance of tin exports as a source of foreign exchange earnings.

Table 4. Bolivia: leading exports (1955-1975)[a]

Year	Products	Share of export value
1955	Tin	66.5%
	Tungsten	18.2%
1960	Tin	81.3%
	Lead	9.1%
1965	Tin	84.9%
	Antimony	5.4%
1970	Tin	56.8%
	Antimony	16.3%
1975	Tin	38.7%
	Petroleum	25.8%

[a] Source: Wilkie, James W., 1980, p. 392.

Consequently, it can be seen that Bolivia still is a raw material exporting country. The bulk of her exports originate in the mining sector, and only in the last few years has the importance of the hydrocarbons industry increased. This implies that for the major part of this century the Bolivian economy has been tied to the fate of a few metals, and tin in particular, in world markets. This dependence places the country in an unstable and uncertain condition.

Due to its structure and evolution, the mining industry has not been able to provide the degree of development that could be expected from its importance. Until the early 1950s, the production and marketing of tin and other mineral exports were in the hands of private enterprises. Three of these enterprises acquired impressive economic and political power, which permitted them to effectively control the government and foster their own interests. Penaloza (1953-1954) points out that even as late as 1920, only 20 percent of government revenue was obtained from the tin industry, at a time the industry accounted for more than 70 percent of total export value and its gross sales were three and a half times larger than the national budget.

After tin firms were nationalized in the early 1950s, the government-controlled mining industry has been operating unprofitably because of surplus employment, labor unrest, undercapitalization, depleting mineral deposits, and unfavorable trends in the international market. Consequently, in the decades in which large profits were generated by the mining industry, they were largely channeled out of the country by their private owners. After the nationalization of the large mining companies, the state-controlled mining enterprise has continuously required support.

Understanding of the negative consequences that result from a monoproductive economic system has led planners and policymakers in Bolivia to attempt the diversification and promotion of the country's exports. As segments of transport infrastructure were completed, which linked the lowlands with other regions of the nation, policymakers saw a role for the agricultural sector in both import substitution and export diversification. Transportation improvements permitted Bolivia to initiate exports and replace imports of products like sugar, rice, construction woods, beef, and coffee with domestic production.

CHAPTER III. THE BOLIVIAN BEEF-CATTLE INDUSTRY

Introduction

Bolivia has the potential to become an important and efficient cattle and beef producer and exporter in the years ahead. This has been supported by several observers. Vivado (1969, p. 7) indicates that there is not the slightest doubt that there exist sufficient pasture lands to greatly increase cattle production in the Bolivian tropics. Gollnick (1966, p. 1) has asserted that:

> "Bolivia has an excellent potential for beef production in the Oriente to supply both domestic and foreign demand if modern production and marketing practices are introduced."

More recently, a FAO/World Bank commission (1978, p. 4) has concluded that:

> "given the low extraction rates and body weights, and the generally low stocking rates prevailing in the country, there are excellent opportunities for expanding cattle production."

A brief history

During the Spanish process of colonization, several attempts were made by the Crown and private individuals to explore and dominate the Amazonic hinterland in the New World. However, all efforts in this direction ended in failure. Confronting this situation, the Crown turned for help to the Jesuits, who initiated during the 17th century a systematic and carefully planned settlement of the region. The Jesuits introduced practically everything that was necessary to support the missions. As De Mesa and Gisbert (1970, p. 92) report, the missionaries introduced about 200 head of cattle, which formed the foundation the present cattle population of the Bolivian lowlands.

The criollo breed of cattle that was introduced into the Bolivian lowlands in the 17th century was able to adapt to the new environment and did multiply rapidly. As in other regions of the New World, this success represented a key element in the process of colonization. Cattle provided a reliable source of food to the colonists in their settlements and to adventurous conquistadors and explorers in their journeys. However, no breeding herds of cattle were introduced in the Bolivian highlands, as it was difficult for the animals to adjust to the high altitudes.

With the discovery of Potosi's rich silver deposits, there was a massive migration of individuals to the Bolivian highlands after 1545. Colonists and adventurers usually left from Panama and after a two month sea voyage arrived in the port of Callao. From this port they needed to follow the old Inca road, through the Andean mountains to reach Potosi. The journey from the coast to Potosi represented a 1,400 mile journey. Subsequently, the city of La Paz became a passing point for travellers of this route.

Because of their favorable location around 1750, the lowlands in Northern Argentina had become the source of livestock to feed the densely populated city of Potosi and its neighboring minefields. The town of Tucuman in Argentina became an important livestock center inasmuch as it was only 700 miles away from the mines. Rouse (1977, p. 69) indicates that these circumstances led to the establishment of the first Argentinean breeding herds of cattle. Unfortunately, the golden years of Potosi in colonial times did not encourage the development of cattle production activities within the territory that was later to be Bolivia.

When the Jesuits were expelled by the Spanish Crown in 1776, the missions and their cattle were mostly abandoned as the indigenous population returned to their former way of life or escaped from incoming slave hunters. Cattle were allowed to become untamed and multiplied without control. By the time of the independence wars, due to the absence of market outlets and the scarce human population of the Bolivian lowlands, cattle numbers had increased significantly.

At the turn of the 20th century, the rubber boom attracted large numbers of people to the northeastern lands of Bolivia and caused a new wave of development, the first since the departure of the Jesuits more than one century before. During the two decades that the rubber boom lasted, the region generated wealth and prosperity. Many modern cattle operations can be traced back to this golden period. Unfortunately, around 1910 the boom was over, and the region returned to its previous state of dormancy.

During the Chaco War (1932-1935) when practically the entire country's able-bodied male population was drafted, cattle ranches in the lowlands were largely abandoned and the animals again returned to the wilderness. Until the late 1940s, there was no connection between the population centers of the highlands and valleys of the country and the cattle producing regions of the lowlands. Consequently, beef demand in the principal cities of Bolivia and the minefields was satisfied with cattle imports from Argentina. Lacking market outlets, cattle in the lowlands of Bolivia were practically valueless as Great Plains cattle were before the American civil war. There are reports indicating that in this period cattle in the lowlands were slaughtered solely for their hides, which were exported to Peru and Brazil. In this manner, the cattle population of the region was reduced again.

With the introduction of air transportation in 1947, beef exports from the lowlands to consumption centers in the country grew impressively, as Table 5 shows:

Table 5. Air shipments of beef from the lowlands to the highlands of Bolivia[a]

Year	Metric tons of beef
1947	281.4
1949	2,278.5
1950	1,871.1
1952	5,422.8

[a]Source: Hunting Technical Services Ltd. and Manuel Vivado P. y Asociados - Consultoria Agropecuaria, 1973, p. 3.

In the early 1950s, lack of foreign exchange prevented meat imports. The government then opted to subsidize the consumption of beef from the lowlands. In the period 1948-1960, the cattle industry of the lowlands was not seen as a growth sector, but rather as a plentiful resource to be harvested without control. Indiscriminate slaughter of cattle in this period greatly diminished the national herd. As a consequence, some large beef processing plants which had been built in the lowlands and in La Paz had to close down due to lack of raw material.

After 1960, several small and rudimentary plants, which could operate with smaller throughput volumes were consolidated in the lowlands. In the cities of La Paz, Cochabamba, Oruro, and several Comibol minefields cold storage facilities were built, to receive beef shipments air-transported from Beni.

Cattle regions

The cattle regions of the country can be studied in relation to the three major geographical divisions of the country, that is, highlands, yungas and valleys, and lowlands (Figure 3).

The Altiplano in the highlands presents varying conditions for cattle growing. In North Altiplano, the waters of Lake Titicaca and the existence of a good road infrastructure permit the area to be an important cattle producer oriented to serving consumers in the city of La Paz and Southern Peru. Central Altiplano has the greatest potential for the production of cattle in the highlands. This area has good forage production and water supplies. South Altiplano is the most inhospitable part, and hosts only a reduced, dispersed, and low quality cattle population. In general, in the highlands there is not sufficient water, land, and pastures to support a large cattle herd. Due to the predominantly agricultural character of the region, cattle are considered a source of work power, meat, and milk as well

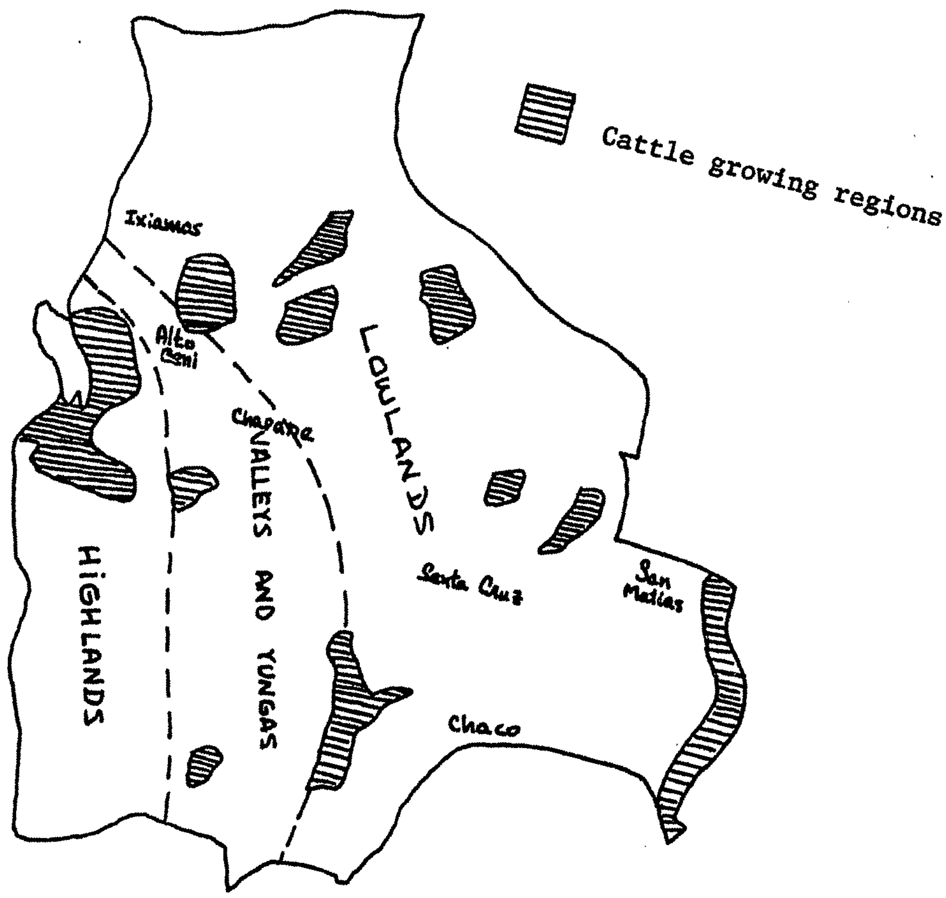


Figure 3. Bolivia: cattle growing regions

as a store of value and a factor of prestige.

In the subtropical climate and steep terrain of the Yungas, the cattle population is small and dispersed. No intensive cattle growing activities have developed in this region. In the department of La Paz, the area known as the Alto Beni has been indicated to have availability of rice, cocoa, and sugar byproducts. Hunting and Vivado (1973, p. 11) have found that small cattle fattening operations for cattle brought from Beni already existed in the Alto Beni in the early 1970s. As production areas in Beni are linked with La Paz with road transportation, most observers expect a significant increase in cattle fattening activities in the Alto Beni.

The Chapare is a tropical valley which is expected to become an increasingly important cattle fattening area for cattle from Beni. This valley is currently linked with production areas in Beni by river transportation and with the city of Cochabamba by highway.

In the temperate valleys, cattle activities are relatively minor. There are large numbers of small scale arable stock farms, due to the large human population and scarce land. Rainfall is unreliable and irrigation water is limited. Most observers believe that it is unlikely that the cattle industry in this region will expand significantly in the coming years, although there may be some potential for fattening activities. Vivado (1966, p. 4) has compared these valleys with the United States cornbelt, to give an idea of their fattening potential. For the time being, however, only a steady supply of discarded cows and old oxen for consumption in the vicinity can be expected.

The central valleys have constant temperate climate, and both agricultural and livestock activities are of importance. There already exist a well established dairy industry, and there is a good potential for cattle growing and fattening activities. The southern valleys provide beef to the minefields in the Potosi area and southern Oruro.

In Bolivia, the lowlands offer by far the best conditions for cattle growing and fattening activities. This is especially so in the natural prairies of Beni, Ixiamas, and San Matias, which together host about three quarters of the national herd.

The northern part of the lowlands, department of Pando, consists of natural prairies in the midst of tropical jungle, usually located at great distances from market outlets. Presently, there is a reduced and sparse cattle population, although there is a significant production potential.

By far, the most important cattle region in the lowlands and in the country is the Beni area, which due to its importance in the context of this dissertation is treated separately.

The Santa Cruz area is one of the most active cattle trading centers and beef markets in the country. In general, this area has a larger human population and higher land costs than other regions in the lowlands. Increased investments are required for land clearing and planting of pastures. It is believed that the area is more appropriate for semi-intensive production, and for the fattening of cattle incoming from Beni and Chaco.

The Chaco region is located south of the city of Santa Cruz, down to the Paraguayan and Argentinean borders. It has a uniform topography, with scarce water resources and a well established cattle industry. Livestock activities represent the main economic activity as well as the main source of family income. The greatest constraint to the development of the cattle industry in this region is the scarcity of water, especially during the dry season which lasts from April to October. Efforts to locate underground water have generally been unsuccessful. Because cattle depend mostly on browsing, it is estimated that the animal carrying capacity of land in this region is one head per twelve hectares.

In both the Santa Cruz and Chaco regions, cattle growing is a traditional activity, with extensive production practices and low land productivity. According to a BAB project (1975, p. 49), close to two million cattle can be introduced in these areas, inasmuch as 70 percent of the suitable land area is still unemployed.

Because of seasonal production patterns in each region, supplies from each source vary throughout the year. When supplies from Beni decrease (July to September), cattle flows from the Altiplano to the city of La Paz and the minefields in the highlands increase. Supplies from Beni are greater during the rainy season (October to February), and because they tend to saturate the market, supplies from the Altiplano are reduced. In these circumstances, illegal exports of live cattle from the Altiplano to neighboring Peru and from Beni to Brazil increase. It has not yet been clearly determined whether the substitution of Beni for Altiplano beef in times of increased supplies reacts to consumer preferences or to decisions made by wholesalers.

Distribution of the cattle and beef output

Table 6 shows the form in which regional cattle and beef output were distributed among the major producing and consuming regions of the country during the period 1976-1977. There are some inconsistencies in JUNAC documents concerning the distribution of Altiplano cattle output. While in Table 6, no exports to Peru from the Altiplano are entered, in another publication, JUNAC (October 1979, p. 17) estimates an export volume of 18,000 head to Peru for the year 1977. Consequently, it is likely that the Altiplano cattle population presented in Table 6 is underestimated. The information contained in this table is shown in graphical form in Figure 4, where prevailing transport modes are indicated.

Ranch and herd sizes and income levels

Land area, herd sizes, and income levels for cattlemen in Bolivia vary between and within regions. Beni hosts the larger herds, while the smaller herds are in the Chaco, highlands and valleys. As Table 7 indicates, the Chaco area has the greatest number of small cattlemen. These smaller cattlemen are generally able to provide a better control for their animals. Birth and branding percentages are usually higher for these cattle operations, although mortality rates may be higher

Table 6. Distribution of cattle and beef output (1976-1977)[a]

Origin	Cattle population (no. head)	Take off (no. head)	Destination	Number head
Beni	1,850,000	202,000	Local	30,000
			La Paz	54,000
			Mines	34,000
			Other dept.	36,000
			Exports	48,000
Santa Cruz	800,000	103,000	City S.C.	45,000
			Rural	30,000
			Cochabamba	7,000
			Exports	21,000
Alti-plano	340,000	62,000	City L.P.	36,000
			City Oruro	9,000
			Mines	13,000
			Rural	4,000
Valleys	500,000	45,800	City Sucre	6,500
			City Tarija	8,200
			City Potosi	10,600
			Rural	13,000
			City Cbba.	7,500
Total	3,490,000	412,800		412,800

[a]Source: JUNAC, April 1978, p. 5.

Table 7. Average herd size and number of cattlemen[a]

Region	Average number of heads	Number of cattlemen
Beni	778	1,372
Eastern Santa Cruz	329	239
Central Santa Cruz	229	135
Chaco	123	1,555
Mesotermic valleys	91	

[a]Source: Hunting Technical Services Ltd. and Manuel Vivado P. y. Asociados - Consultoria Agropecuaria, 1973, p. 23.

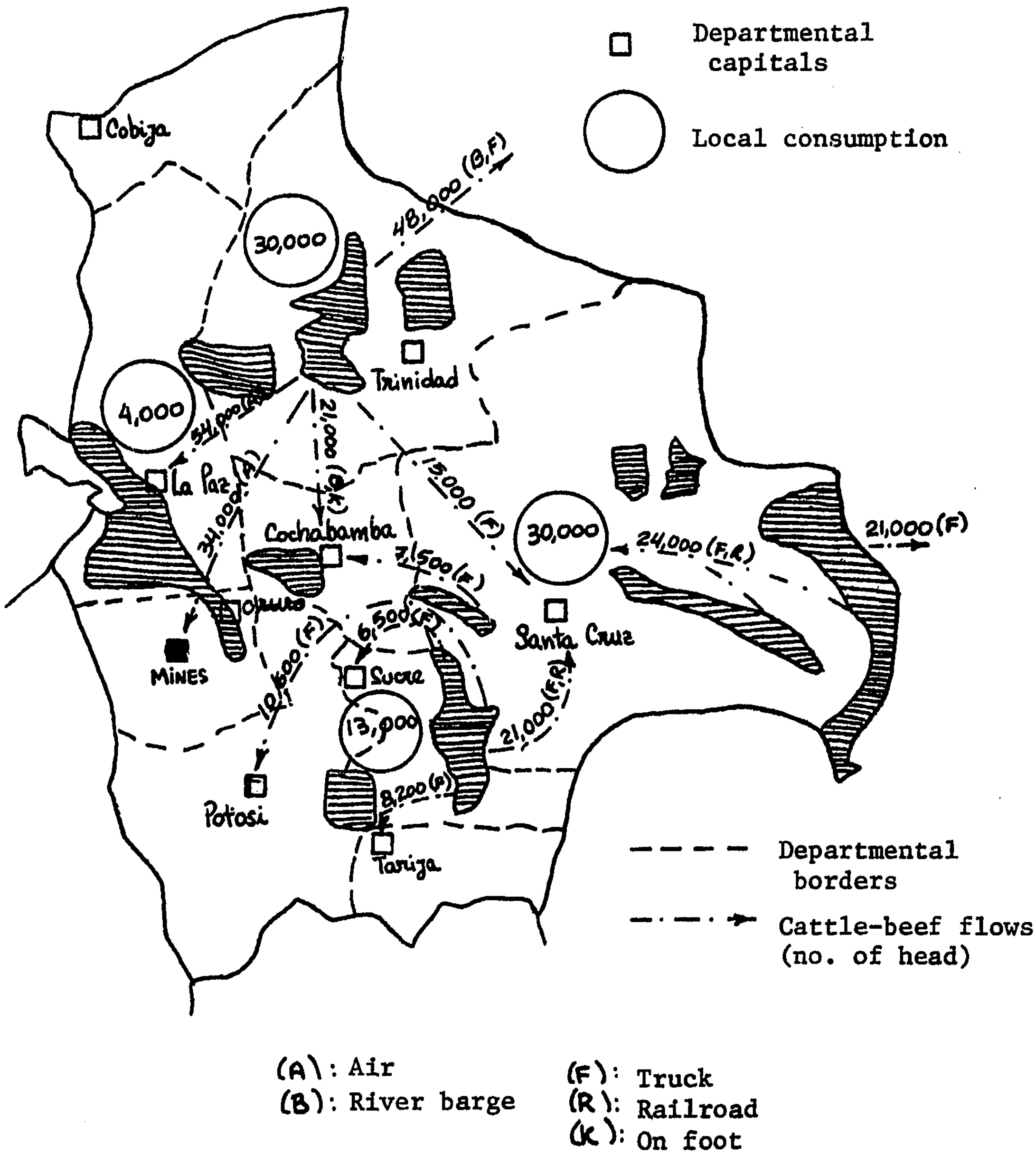


Figure 4. Bolivia: cattle regions, live cattle and beef flows, and transportation modes (1976-7) (JUNAC, April 1978, p. 7)

due to lack of vaccines and veterinary care. In Beni and Chaco, 53.6 percent and 94.9 percent of the cattlemen own fewer than 300 head. In Beni, 88 percent of the cattle growers own fewer than 1,000 head. while in the Chaco, this percentage rises to 99 percent (Hunting and Vivado, 1973, p. 2). In Beni, 56 percent of the cattle are in herds of 1,700-7,000 head, being the property of 11 percent of the cattlemen of the region (JUNAC, April 1978, p. 2). In this department, 67 percent of the cattlemen own herds with 100 to 1,000 head. The group formed by these cattlemen, according to the Hunting and Vivado study (1973, p. 13), influences public policy to maintain price controls. It is believed that this latter group is the one in greater need of credit and technical assistance.

Cattlemen in Beni have the lowest incomes in the industry, due principally to high transportation costs, which amount to 15 percent of the retail price of the product (JUNAC, April 1978, p. 15). The income of cattlemen depends basically upon location because of transportation costs. Cattlemen of Reyes, San Borja, Trinidad and Santa Ana, which are closer to the markets in the highlands have higher incomes than those cattle growers located in distant places such as Magdalena and Riberalta. It is likely that the highest income levels per head of cattle are obtained by cattlemen in the Altiplano and valleys, who can provide good control to their animals and are conveniently located in relation to beef markets.

Production practices

Production of cattle in Bolivia is considered to be primitive in the extreme. As one observer indicated, in Beni, cattle multiply only because God wills it. In the lowlands, extensive production methods are employed, there is a lack of technical innovation, and investments in the cattle industry are low. Cattle growers have in general not shown ability nor willingness to improve their herds and pastures. The CNRA teams that visited 266 ranches in Beni in 1973, reported that 92 percent of the ranches practiced traditional cattle growing methods. Notoriously absent were methods to improve pastures or control the breeding season (CNRA, 1976, p. 175). In several regions of the country, cattle owners see their animals only at the time of branding. This is why Vivado (1966, p. 7) has indicated that the majority of the cattlemen have only an approximate idea of the number of animals they possess. Because cattle are allowed to eat what they like, they tend to gain weight in times of abundant and fresh pastures (December to May) and lose weight during the dry season (June to November). Due to almost total dependence upon natural pastures for feeding without rotation, the fattening and finishing period is considerably lengthened. Table 8 shows some of the production statistics.

Table 8. Cattle production statistics[a]

Concept	Statistic
Branding rate	50-55 percent
Adult mortality rate	3 percent
Female culling rate	20 percent
Extraction rate per year	13 percent
Birth weight	24-27 Kgs.
Weaning age	8 months
Weaning weight	80-100 Kgs.
Cow age	30-36 months
Marketing age	36-54 months
Cows per bull	6

[a]Source: Hunting Technical Services Ltd. and Manuel Vivado P. y Asociados - Consultoria Agropecuaria, 1973, p. 4 and Vivado P., 1969, p. 8.

Branding percentage is used as a proxy for calving percentage, because cattle growers count their calves only at the time of branding. Branding takes place when calves are from six to nine months old.

Slaughter of breeding females is quite common in the industry. Hunting and Vivado (1973, p. 74) have estimated that 21.89 percent of all animals slaughtered in Bolivia are pregnant females.

It must be acknowledged that cattle production statistics in the country are not accurate due to inadequate management practices on the part of cattle owners and to the absence of public recording and information systems. Because cattle ranches in the lowlands are located in areas of difficult access, it is difficult to conduct censuses or surveys of the industry. This is why to the present there is not a nationwide livestock census.

<u>Slaughter facilities and practices</u>

Slaughter facilities in Bolivia are in general most primitive. Artificially low product prices and the levy of slaughter fees by cities have discouraged the upgrading of slaughtering facilities, most of which are about sixty years old. Standards of hygiene and cleanliness are low and inspection services are generally absent.

Slaughter animals are driven violently and with intense whipping. Corrals are generally inadequate and do not safeguard cattle against being hurt or bruised. In most cases, treatment of the animals is inhuman and they experience slow and painful deaths. Animals are killed with knocking hammers in La Paz, Tarija, Potosi and Santa Cruz, and by knife bleeding elsewhere. Pistol cartridges are generally not used because of their higher cost.

The large number of slaughter facilities is another problem faced by the industry. There are more than two hundred plants of different sizes in the country. More than one-half of these plants are publicly owned and managed by government bodies. About one-third are owned by private individuals, COMIBOL, and some processing cooperatives. Eight slaughterhouses belong to major municipalities in departmental capitals. About one-half of the slaughterhouses in Bolivia are located in the lowlands, and about sixty of them in Beni.

Throughout the country there is a tendency for each locality to have its own slaughterhouse, without taking account of production costs, economies of scale, location factors, nor hygienic conditions. In the case of publicly owned plants, there are political pressures to build them, inasmuch as they represent signs of progress and can be completed quickly. Most of these facilities are primitive and have only the bare essentials. Few have refrigerating chambers or a good water supply. The lack of skilled labor is prevalent throughout the industry, as is the use of child labor. Low cost child labor is primarily employed for skinning operations.

Cold store facilities

There are sixty-five cold store facilities in Bolivia, with a combined capacity of 1,529 metric tons of beef. However, four plants with an aggregate capacity of 522 metric tons do not operate. Rental fees for cold storage are high, being approximately $b 54 per carcass per day. In Beni, in 1978, there was a cold storage capacity of about 230 metric tons for the output of sixteen slaughterhouses. These chilling facilities are used mostly in cases of emergency, when planes are delayed or grounded, or flights are cancelled. Because these facilities are not used for meat aging, they do not have an impact upon product quality.

In the city of La Paz, refrigerated capacity equals 662 metric tons, of which only 157 metric tons are in operation. There exist about twenty-two small private cold storage facilities, with an average capacity of seven metric tons, an average volume of thirty cubic meters. The Los Andes plant with a capacity of 4,000 cubic meters, which was built in the early 1950s, is believed to be obsolete.

Four private firms own fifty-five metric tons of refrigerating capacity in the city of Santa Cruz. The city of Cochabamba has six cold storage facilities with a capacity of 185 metric tons of beef. The city of Oruro has seventy-eight metric tons capacity, which are used mostly to store beef for COMIBOL.

It is likely that Bolivia's refrigerating facilities and practices will undergo significant modifications as surface linkages linking the Beni with the highlands and valleys are completed, if refrigerated trucks displace airplanes for transportation of beef.

Marketing channels

Marketing channels for cattle and beef vary among regions. There exist three marketing procedures for beef in Beni. One arrangement consists of middlemen buying meat at the farm gate, then forming a herd which is subsequently driven to a slaughterhouse and sold to wholesalers, who later fly the carcasses to the highlands. Another approach consists of ranchers bringing their cattle to the airstrip and selling them directly to the wholesaler or slaughterer. Finally, ranchers may slaughter, fly, and sell beef directly to retailers.

In the principal consumption centers, beef from Beni is marketed by large scale wholesalers who own cold storage facilities. These wholesalers draw lots to determine dates and places in Beni for their beef purchases. Sale conditions with cattle owners are usually arranged by shortwave radio. Planes are rented from several supplemental carriers. Most wholesalers rent two weekly flights, although a few rent daily flights.

Slaughter fees may be paid by the buyer or by the cattle owner, depending upon which one retains the edible by-products. Beni beef is unloaded at El Alto airport in the city of La Paz, from where it is transported to cold stores in rented trucks. Quarter-carcasses are then sold to some eighty to one-hundred retailers. Usually, retailers pick up their beef purchases from a cold store.

Price controls and spreads

Beef price controls have existed in Bolivia in different forms constantly since 1959. These price ceilings have been established to permit beef consumption by poor households in urban areas. MICT fixes maximum wholesale prices at the national level, while municipalities fix maximum retail prices in their jurisdictions.

Before the 1972 monetary devaluation, in which the Bolivian peso was devalued from twelve to twenty to a U.S. dollar, beef prices were set at $b 6.40/Kg. at the producer level and at $b 9.90/Kg. at the wholesale level. Such prices were determined without regard for quality nor type of cut. Although official price ceilings are uniform for all cuts, in practice, the best cuts are retailed at premium prices. Low income consumers pay official prices for a mixture of low quality cuts, fat, and bones. Kelly has pointed out that meat purchases by poor households at the official prices are composed by fifty percent fat, nerves, and bones (BAB, 1970, p. 101).

In the period 1972-73, beef markets for Bolivian Beef were opened in neighboring Chile and Peru. As a consequence, the Bolivian government found it increasingly difficult to maintain the domestic price controls and attempted to prevent exports. However, the new foreign demand had strengthened the negotiating capacity of cattle-beef producers in the country. By holding supplies off the internal market, producers forced the government to reach an agreement. Under this agreement, Bolivian beef producers sold their product at lower prices in the domestic market and obtained export quotas in exchange.

In October 1973, a new level of controlled prices was established, in which beef prices at the producer level in Beni were set at $b 12/Kg. Prices wholesale CIF El Alto-La Paz were set at $b 15.5/Kg., and between $b 14.70 to $b 17.50/Kg. at the retail level.

With the exception of the cities of Trinidad and Santa Cruz, price spreads between cuts of different quality are considered to be too narrow. In La Paz, in early 1979, pure bone was priced at $b 18/Kg., while boneless meat sold for $b 22/Kg., with obligatory tie-in with bone for retail purchase. The fact that consumers of beef must purchase an often unwanted amount of bone results in an effective increase in the price of beef. Hunting and Vivado (1973, p. 122) have estimated this increase to range between 12 and 27 percent.

In Santa Cruz, a grading system for live cattle was implemented in 1976, which provided incentives for fattening and finishing. Before slaughter, cattle were graded and priced in three categories. However, due to insufficient planning and lack of control, this experiment ended in failure. Consequently, at the present time, there is no grading of live cattle anywhere in the country.

Policies and strategies for development

During the last fifteen years, the Bolivian government has employed several consultants to diagnose the situation of the beef cattle industry, so as to formulate appropriate development policies. Unfortunately, and in spite of all the recommendations offered by the various consultants, the country does not yet have a well defined, comprehensive set of policies for the cattle-beef industry. Changes in economic and political conditions in the country have prompted the national government to adopt varying attitudes toward the industry. Such attitudes have included treating cattle as a free resource, as a fundamental staple for the urban population, as an export commodity, and in recent years, as a vanishing product in need of government support. Changing attitudes have resulted in variable policy actions.

The study that was undertaken in 1973 by the Hunting and Vivado consulting firm is by far the most ambitious, having covered the whole beef marketing process. A specific investment program was suggested, which included construction and upgrading of slaughterhouses, establishment of a national meat board, improvement of transportation facilities, and establishment of plants for the treatment of by-products.

The fundamental component of the Hunting and Vivado proposal was investment in slaughterhouses, which was to amount to \$1.41 million for the years 1974-1976. The national meat board to be created was given a crucial role in the development of the industry. This agency was to be an advisory body to the government in matters of cattle-beef policy, and responsible for the collection of statistics, grading, pricing, and export policies.

No investments were made as a result of the Hunting and Vivado recommendations. Some observers attribute this to inappropriate conditions prevailing in the country, while others point out that the integral, all-out approach implied in the study was not compatible with the primitive conditions prevailing in the industry. Even though JUNAC praises the good and detailed technical recommendations of the study, it deplores the absence of operating mechanisms to implement the recommendations, that is, what was left in the hands of the never to be created national meat board.

The proposals of Hunting and Vivado were largely ignored because the government did not provide the necessary support. The ever present conflict of objectives between price incentives to develop the industry and price controls to provide cheap beef to the urban population was not solved by the authorities in charge. Industry groups may have also played an obstructing role, inasmuch as a robust meat board would have meant increased regulation and control of the marketing process.

The FAO and WB mission that in 1977 visited the country to identify projects for the beef industry had the impression that conditions had changed since the Hunting and Vivado study was published. At the time of its study, the mission pointed out that seven major municipalities were eagerly seeking to improve their slaughtering facilities and consumers were demanding better quality products. Moreover, some slaughterhouses, especially in Santa Cruz and Cochabamba were already operating beyond their capacity, and cattlemen associations were actively supporting slaughterhouse improvement moves. The mission concluded that the industry was ready for take off!

The mission suggested the creation of a national meat board, improvements in the transportation system, provision of new slaughter-houses for seven municipalities, and a reduction in the number of slaughterhouses in Beni. Government action was also seen as necessary in setting up standards for new facilities in the meat industry, relaxing price controls on special cuts, abolishing the municipal hide tax, and establishing credit channels. The mission stressed the fact that, without proper government action, investment in the industry would decrease and beef imports could actually be taking place as early as 1981.

Adopting a strategy similar to Hunting and Vivado, the FAO-WB mission assigned to the meat board the general responsibility for the project and included investments in slaughter, transportation, retail and by-products facilities. Development of the demand for better quality beef in seven department capitals, establishment of realistic standards, and modification of the existing pricing practices were also seen as necessary.

The recommendations suggested by the FAO-WB mission remain at the proposal stage, the national commitment needed to implement them being absent.

A more recent set of proposals to develop the country's beef industry was formulated by JUNAC. In a document published in April 20, 1978, JUNAC suggested a step-by-step approach, which could be progressively broadened. Starting out with a "model" market, conditions in the industry would be gradually improved. Such a model market would be initially located in the area of Santa Cruz. This was considered appropriate because this is an important producing and consuming area, in relative isolation from the rest of the country, where there have been some initiatives to improve the cattle marketing process. Later on, the Trinidad area could become a second model market, based on the experiences obtained in Santa Cruz.

JUNAC also assigns a key role to improvements to be made at the slaughter level. The need to nationalize slaughter operations, to facilitate exports of special cuts, is emphasized.

In October 1979, JUNAC presented a more comprehensive development strategy for the Bolivian beef industry, which suggested the need for an integral action rather than a step-by-step approach. This can be explained by the failure of the Santa Cruz live cattle grading experiment, which JUNAC attributes to the stiff price controls which did not provide adequate returns to cattle growers.

CHAPTER IV. THE TRANSPORTATION SYSTEM

Introduction

The Bolivian transportation system is constrained by a series of natural conditions and geographical barriers which inhibit integration among regions. In the western part of the country, the Andean mountain range poses a gigantic natural barrier to the movement of people and goods between the lowlands and the highlands and valleys. In eastern Bolivia, numerous rivers and streams crisscross the landscape and cause seasonal flooding. Most of these watercourses flow towards the northeast, to join the Amazon river in Brazilian territory.

In addition to these natural features, the country's transportation infrastructure has been laid out without any unifying criteria, oftentimes responding solely to regional, sectoral, or international pressures.

Until the introduction of railroad transportation in the late 19th century to serve mining interests in the highlands, all transportation of people and goods was by human or animal power. The cattle producing areas in the lowlands have historically not been linked to the beef consumption centers of the country, until the introduction of surplus World War II aircraft in the late 1940s.

In recent years, several transportation projects geared to connect the highlands and valleys with the lowlands, and to improve linkages within regions in the lowlands, have begun to be studied and constructed. A few of these projects have been completed, while most others advance at a slow pace due to lack of resources. However, it can be expected that in the course of the 1980s, several of the projects under construction will be completed, with profound impact upon the whole Bolivian society and economy.

In the sections that follow, an analysis is made of the main transport modes in the country, and the existing and planned transportation linkages, with special emphasis upon those serving the cattle-beef industry.

Railroad transportation

The Bolivian railroad system has been laid out to serve the transportation needs of the mining and petroleum industry. Its contribution to the movement of agricultural goods, livestock and beef is relatively minor, and restricted to certain routes. There are approximately 3,700 Km. of railroad tracks in the country, shown in Figure 5. The railroad network consists of two systems:

Western system   This system is composed of one main line and several feeder lines, and is located in the highlands and valleys. The main line connects the highlands with the Chilean port of Antofagasta in the Pacific Ocean. It goes through Viacha, Oruro, Rio Mulatos, Uyuni, and Ollague, having a total length of 1,177 Km., 732 of which are in Bolivian territory. This system serves basically the export and import needs of the mining industry.

Eastern system   This 1,222 Km. system is composed of two

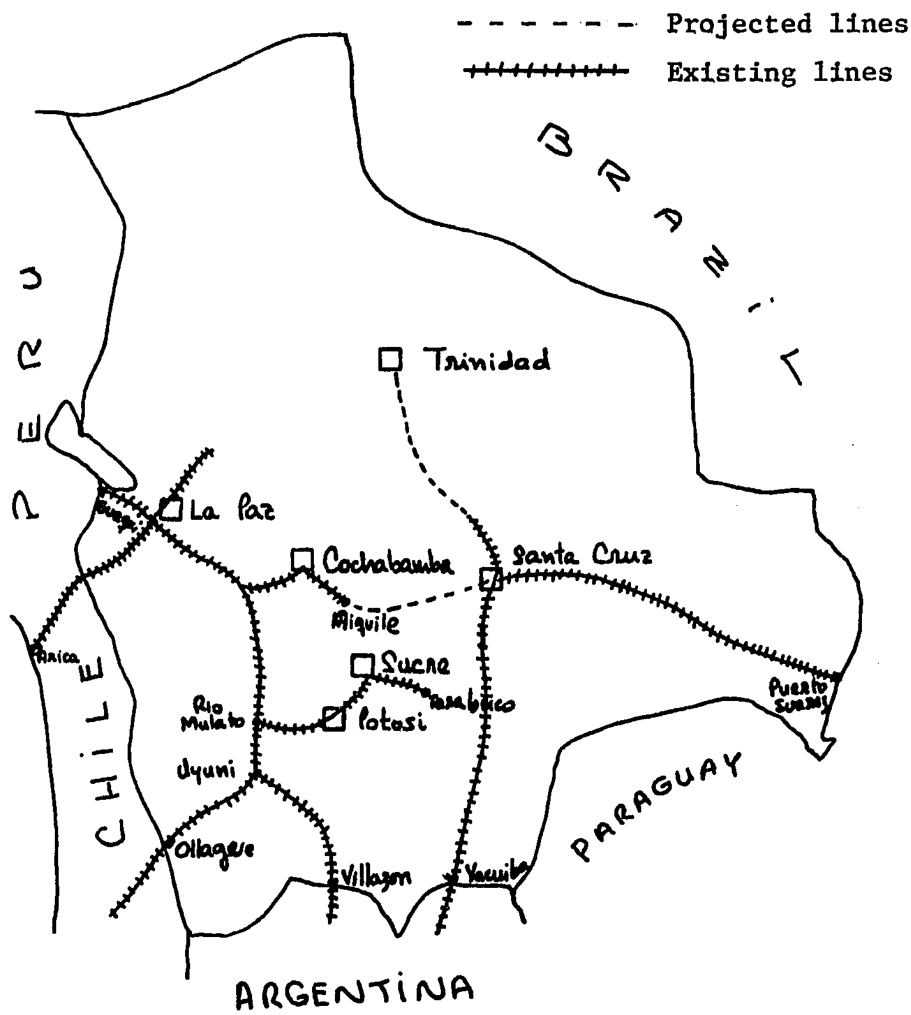


Figure 5. Bolivian railroad transportation system (E. Boyd Wennergren and Morris D. Whittaker, 1975, p. 127; and C. H. Zondag, 1965, p. 127)

lines located in the Santa Cruz area. Both of these lines came in search of the petroleum and natural gas of eastern Bolivia, to satisfy demand for energy in neighboring Argentina and Brazil. These lines are:

Santa Cruz - Puerto Suarez   This 645 Km. line links the city of Santa Cruz with the Brazilian railroad network. Construction having started in 1939, this line was not completed until 1964.

Santa Cruz - Yacuiba   This 539 Km. line connects the Santa Cruz and Chaco areas with the Argentinean railroad network. Constructed as a consequence of a 1941 bilateral agreement between the Bolivian and Argentinean government, this line was officially inaugurated in 1975. Alvarez, et al. (1974, p. 13) pointed out that railroad offers unsatisfactory service. Even though there are stations every 30 Km., due to the lack of sufficient equipment and wagons, cattle bound for Santa Cruz must oftentimes wait several days and occasionally weeks to be transported. Moreover, stations do not have suitable resting and watering-feeding facilities.

Railroad transportation of live cattle is important only in the eastern system. Cattle are transported from eastern and southern production areas for slaughter in the city of Santa Cruz. Of the two eastern lines, the most important is the Santa Cruz - Puerto Suarez, which is estimated to move about 25,000 head of cattle per year.

Railroad projects   The basic plan for railroad construction in Bolivia is to connect the eastern and western systems, and to link the country's railroad network with the waterway system of the lowlands.

The railroad projects likely to have an impact upon the cattle-beef industry are:

Cochabamba - Santa Cruz This project is the last obstacle inhibiting continuous railroad communication between the Atlantic and Pacific oceans. When completed, it will connect the ports of Santos, Brazil and Arica, Chile. Completion of this project has been retarded by lack of funds and the government preference for highways. However, with increasing traffic along the Cochabamba-Santa Cruz highway and rising costs of motor transportation, interest in the construction of this railroad link has been reawakened.

Santa Cruz - Mamore river This project is a part of a future 555 Km. link between the cities of Santa Cruz and Trinidad. The project is a result of a 1967 bilateral agreement between the Bolivian and Argentinean governments to extend the Santa Cruz - Yacuiba line northwards up to a navigable port in the junction of the Ichilo and Grande rivers (which form the Mamore river). If completed, this project would link the Amazon and Plata river systems.

The Santa Cruz - Rio Mamore project consists of three segments. The first one, from Santa Cruz to Santa Rosa, has 104 Km. of extension and is already completed. The second, from Santa Rosa to the Yapacani river has an estimated 104 Km. length and is currently under construction. The third, from the Yapacani river to Puerto Rico on the Mamore river has 140 Km. of extension and has financing assured by the Argentinean government. Progress is slow due to the difficulty of the terrain, the many watercourses, and the continuous increase in construction costs. The extension of this link from the Mamore river to the city of Trinidad, representing around 160 Km., is currently under study.

It is safe to expect that the railroad link between Santa Cruz and the Mamore river will be completed by 1985, while the extension to Trinidad can be ruled out for the next decade.

Water transportation

Within the country, the most important body of water is Lake Titicaca, which in combination with railroads serves as an international link of the city of La Paz to seaports in the Pacific Ocean, In the lowlands there exist more than 16,000 kilometers of navigable rivers. As can be seen in Figure 6, Bolivia's navigable rivers are the Itenez, Mamore, Beni, Madre de Dios, Yacuma, Secure, Chapare, Ichilo and others of lesser importance. These rivers channel their waters into the Madeira river, which is in turn a tributary of the Amazon river. Accessibility to river transportation is a determining factor in regional development of the Bolivian lowlands, and especially so in the department of Beni.

With the completion of highways 1 and 4, from the city of Cochabamba to Puerto Patino and Puerto Villarroel, respectively, such navigable waterways have been connected with the La Paz - Cochabamba - Santa Cruz road network. This relatively recent connection has been gaining increased importance in the transportation of bulky, nonperishable commodities, as well as live cattle. However, the full

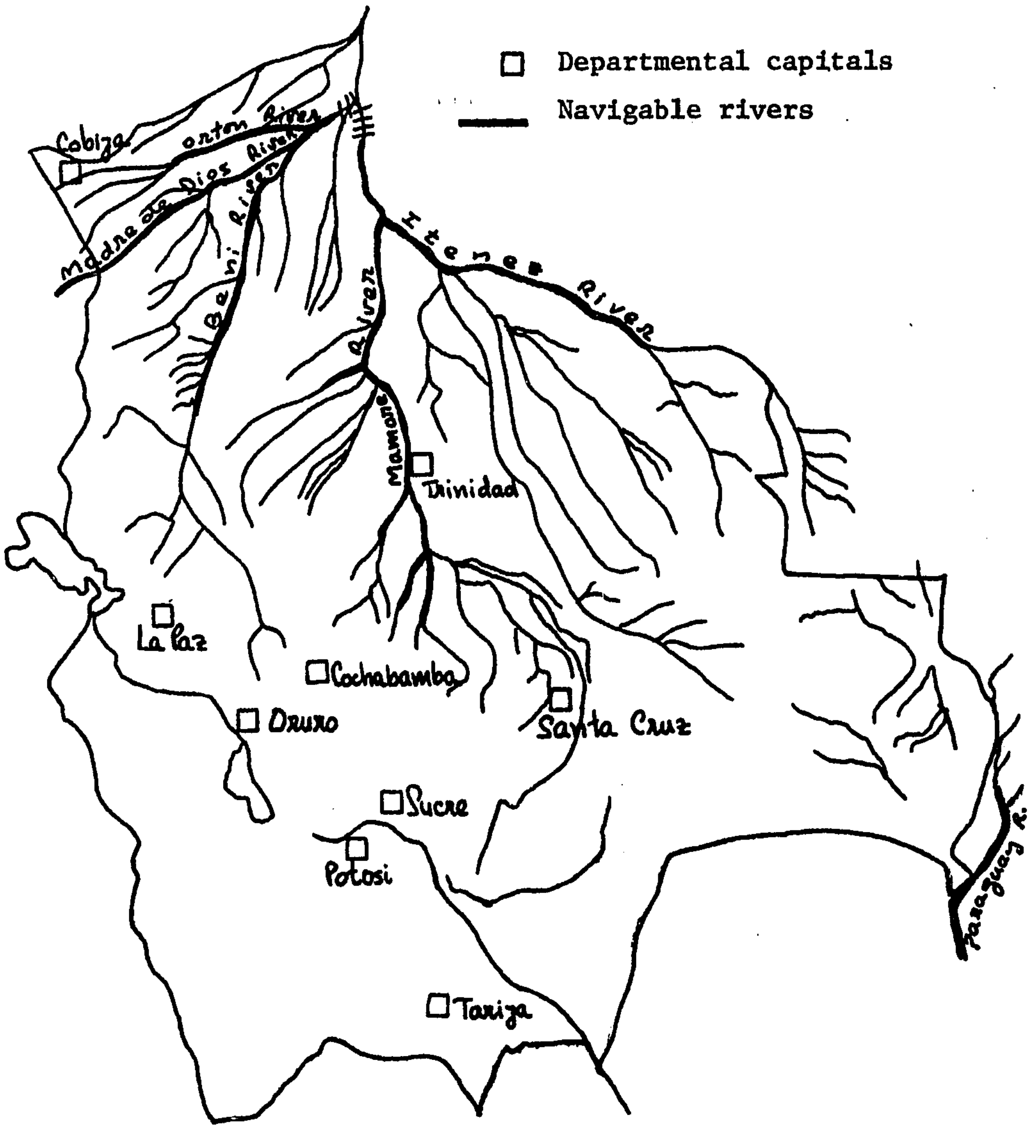


Figure 6. Bolivia: navigable rivers

impact of this connection is yet to be felt.

One of the limitations of this river system is the lack of a direct access to the Madeira and Amazon rivers, as the course is interrupted by the Beni - Mamore waterfalls and rapids. The other potential outlet to the Atlantic Ocean, through the Paraguay river is not yet feasible due to seasonal flooding and swamps.

The Mamore river is the most important navigational medium in Beni. Year-round navigation is possible along its 1,317 Km. course from Puerto Villarroel to Guayamerin. Cattle are transported in river barges from ports on the Yacuma and Mamore rivers downstream to Guayaramerin for export to Brazil. Live cattle are transported from sources along the Mamore river (south of the junction of the Mamore and Yacuma rivers) to the cities of Cochabamba and Santa Cruz, using a river barge-truck combination.

Most of the rivers in Beni are navigable only during the rainy season, from January to August. Due to the high water level, river barges can operate at full capacity, and traffic of live cattle bound to markets in the rest of the country increases.

River barges are generally built by local artisans. One recent account registers 232 barges with an aggregate cargo capacity of 4,000 metric tons (JUNAC, 1979, p. 24). On average, these barges have from 20 to 30 metric tons capacity. The largest barge currently operating in Beni rivers has a cargo capacity of 90 metric tons, or 300 head of cattle. These barges are more properly called pontoons, that is, platforms with lateral protection and propelled with one or two diesel motors. They are used to transport live cattle, fuel, machinery, construction materials, food supplies and various inputs for the cattle industry in Beni.

River transportation in Bolivia is inadequate and traffic density is low. According to one source, there are only a few sections of the rivers where even a scant 10,000 tons may pass in any one year (Daniel, et al. 1968, p. 254). Services are unreliable and irregular. There are not adequate loading and unloading, resting and feeding facilities for livestock at transfer and terminal points. River ports in the Bolivian lowlands are merely natural grounds where cargo can be transferred from river to shore or vice versa.

Motor transportation

There are in Bolivia more than 40,000 kilometers of different types of roads, of which 1,500 are paved, 7,500 have stabilized roadbeds, and the remainder are dirt roads. The Altiplano and highlands, in general, have a well developed road system. As Figure 7 shows, the main road line is formed by the La Paz - Oruro - Potosi - Tarija - Bermejo route. This line has international links with both Peru and Argentina.

The 228 kilometers from La Paz - Oruro link has been sealed, and there exist gravel roads suitable for slow traffic linking Oruro, Potosi, and Tarija. All weather roads are provided by the 453 kilometers Oruro - Cochabamba - Puerto Villarroal and the 458 kilometers Cochabamba - Santa Cruz highway. This latter link, which was sealed in the early 1950s, for many years represented the only year-round surface connection between the lowlands and the rest of the country.

The 225 Km. of road linking the city of Cochabamba and Puerto Villarroel is increasingly being employed, in combination with river barges, to ship live cattle from production areas in Beni to the city of Cochabamba.

Motor transportation is provided by more than 22,000 non-refrigerated eight-ton trucks, with capacity for 10-12 fully grown cattle each. From slaughterhouses to wholesalers in the cities, beef is transported by truck in unhygienic and unsanitary conditions. This is so because open trucks are used and carcasses are piled up in direct contact with the floor. No long distance road transportation of beef takes place in Bolivia at the present time. Due to the lack of refrigerated containers, current regulations prohibit the transportation of carcasses in common trucks when journey times exceed four hours. According to JUNAC (April 1978, p. 30), the lack of adequate refrigerated transportation for fresh beef in Bolivia has encouraged the construction of slaughterhouses in every consuming center.

Figure 7 shows that while the existing road network of Bolivia is concentrated in the highlands and valleys, the projected routes are located in the lowlands. This is due to the importance that the government has attached to the development of the transportation infrastructure in the lowlands, where it is most inadequate. As the ten year plan of roads puts it:

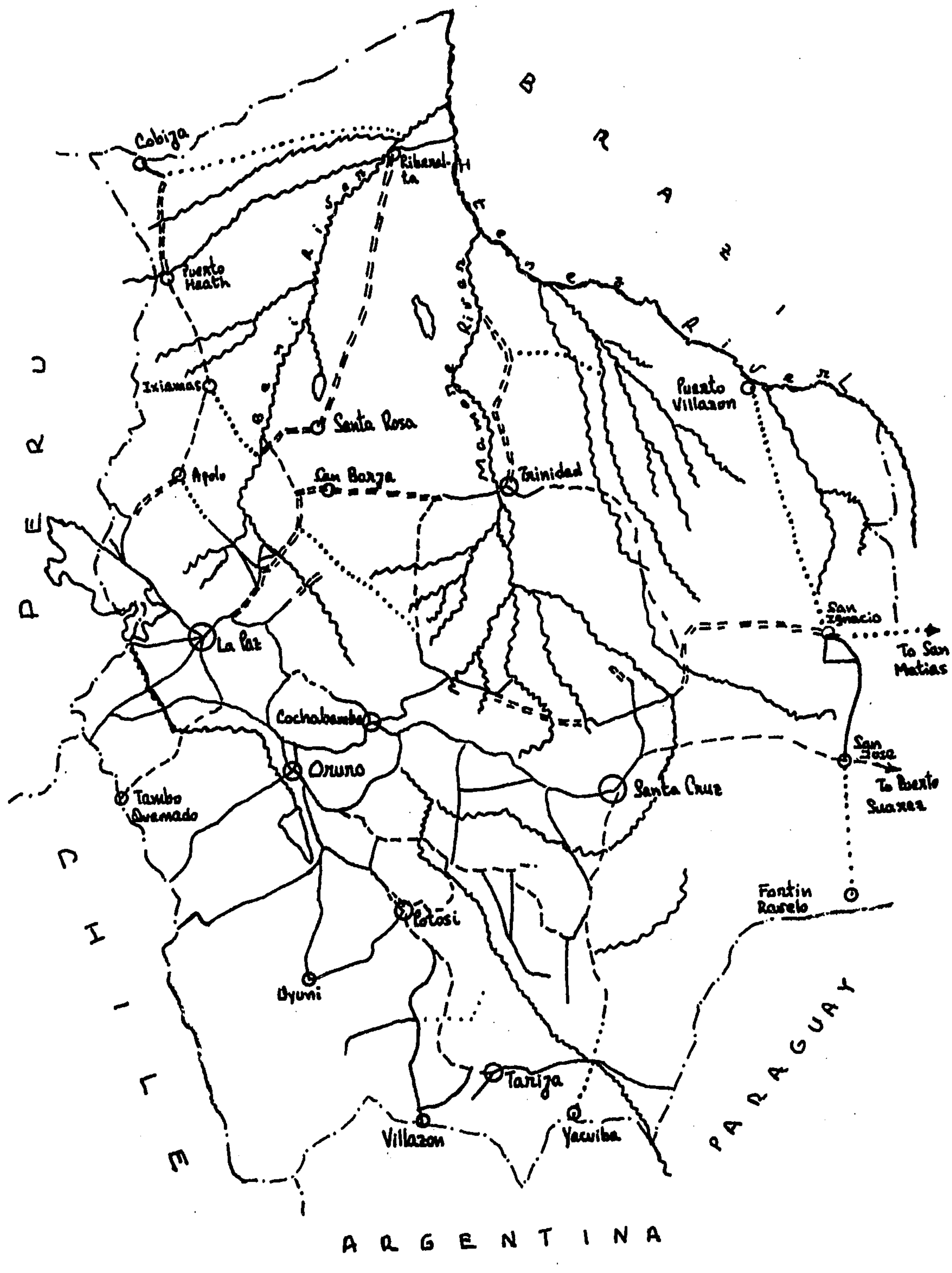
Existing roads

Roads under construction

Roads under study

Possible future roads

Figure 7. Bolivia: existing and projected roads (SNC, 1979, p. 24)


BRAZIL
PERU
CHILE
PARAGUAY
ARGENTINA
Cobija
Riberalta
Puerto Heath
Ixiamas
Santa Rosa
Apolo
San Borja
Trinidad
Puerto Villazon
San Ignacio
To San Matias
La Paz
Cochabamba
Oruro
Santa Cruz
San Jose
To Puerto Suarez
Tambo Quemado
Fortin Ravelo
Potosi
Uyuni
Tarija
Villazon
Yacuiba

> "the road networks towards the north of the country have the highest priority for the integration of the national territory" (MTOPC, 1968, p. 3).

Road transportation is expected to play an increasingly important role for both live cattle and beef movements within the country, as a result of major projects to be completed in the course of the 1980s. Among these projects, the more likely to have an effect upon the cattle-beef industry in Beni are the following:

Projects under construction

La Paz - Beni The future transportation linkages between the departments of La Paz and Beni have been conceived in two different forms. One form consists of a road from the city of La Paz to the Yacuma river, from where it branches in two roads leading to the cities of Trinidad and Riberalta. The other consists of a road-river transportation link, with a road to be built connecting the city of La Paz with Puerto Salinas on the Beni river. This second link will connect the highlands with all points along the navigable extension of the Beni river, tapping important agricultural areas and opening large areas for colonization. Due to the importance of these connections in the context of the present dissertation, we analyze existing conditions along each one of these routes (Figure 8).

The 580 Km. La Paz-Trinidad road is composed of several segments, which are: (a) La Paz-Cotapata has 48 Km. of extension and construction began in May 1977 by the firm Grovers and Sons Company. This segment was expected to be completed by July 1980. (b) Cotapata-Bella Vista has 152 Km. which are already completed. The IBRD has assured funds

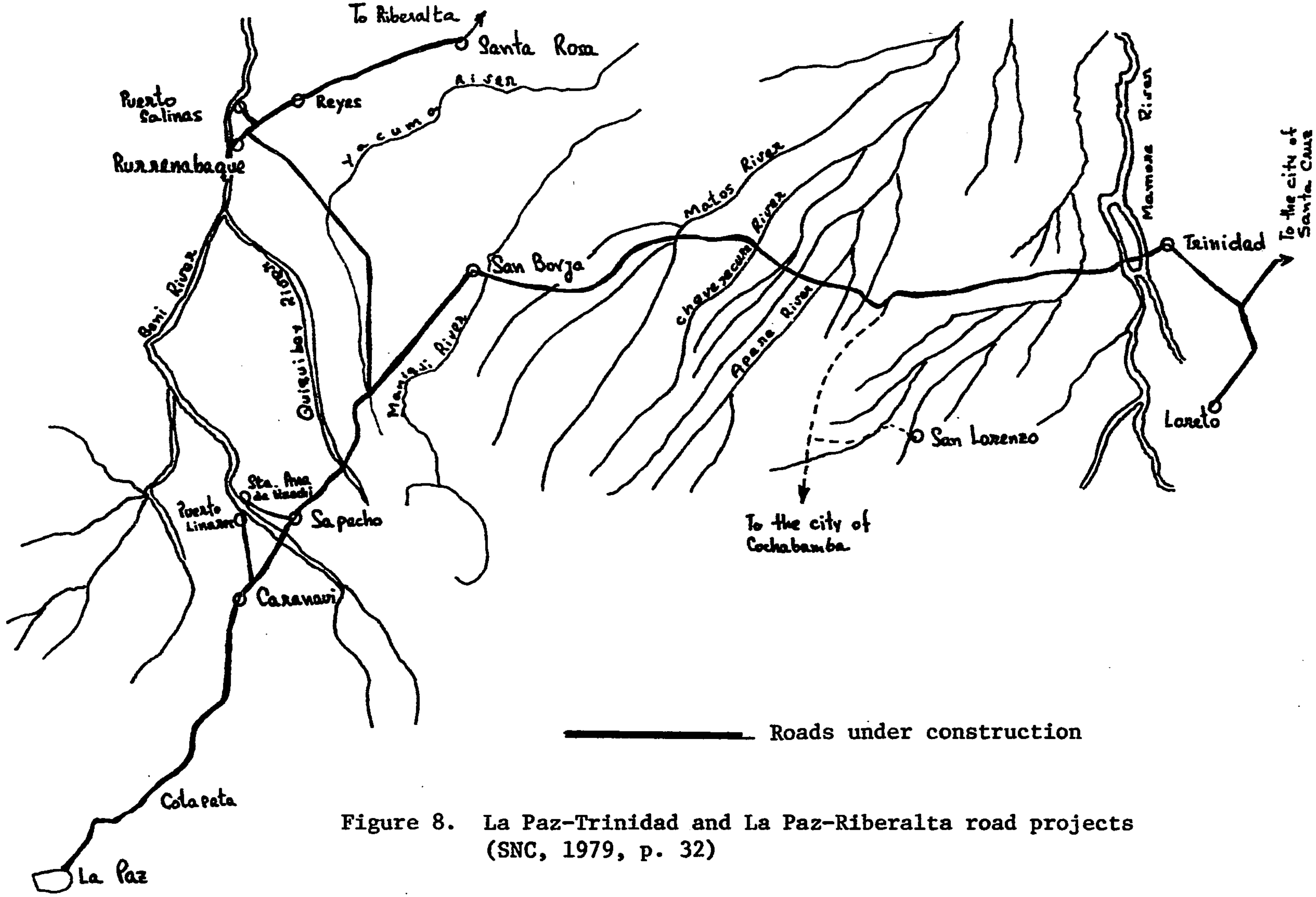


Figure 8. La Paz-Trinidad and La Paz-Riberalta road projects (SNC, 1979, p. 32)

for the Cotapata-Santa Barbara stretch. These funds will be granted by 1981, depending upon the completion of the La Paz-Cotapata route. (c) The SNC initiated construction of the 67 Km. Bella Vista-Quiquibey river segment in 1975. The equipment being used was obtained from a Brazilian loan. By mid-1979, 63 percent of the work had been completed. Insufficient funding and intense rains have slowed progress, but it is estimated that this road will be completed by 1981. (d) Work on the 42 Km. segment between the Quiquibey and Yacuma rivers was initiated in 1977 by the Army, under supervision of SNC. By mid-1979, 30 percent of the construction had been completed. Completion was expected to occur by 1981. (e) The 41 Km. route between the Yacuma river and the town of San Borja has a preliminary road of rudimentary characteristics. This segment is a component of a project package being financed with a Japanese loan. Construction will be undertaken by the SNC under the supervision of one Bolivian and one Japanese private consulting firm. Work was scheduled to begin in July 1979 and be completed at most in 1981. (f) The roadbed of the 228 Km. segment between San Borja and Trinidad was completed in 1978. This is being complemented with the construction of six bridges, and the stabilization of the roadbed. Due to the numerous natural barriers, several years of sustained effort will be required before this segment is operable. It can be expected that this will be achieved in the latter part of the 1980s.

The 934 Km. La Paz-Riberalta road shares the segment La Paz-Yacuma river with the La Paz-Trinidad route. As Figure 8 shows, construction of the Yacuma river-Riberalta road entails completion of several segments: (a) the Yacuma river-Puerto Salinas segment is another component of a package of projects being financed with a Japanese loan. Construction of this 120 Km. road was expected to start after the rainy season of 1979. In late 1978, final revisions of the design were being made, while men and equipment moved into the area. (b) The roadbed of the 24 Km. Rurrenabaque-Reyes stretch has been already constructed by the SNC. The drainage and stabilization of the roadbed still remain to be completed. (c) The major part of the 74 Km. Reyes-Santa Rosa roadbed has been constructed. Lack of funding has made progress along this route slow. (d) The longest segment of the whole route is the Santa Rosa-Riberalta road. Progress along its 420 Km. is slow due to insufficient funding. By mid-1979, 30 percent of the construction had been completed. A 40 Km. penetration road has been opened from the Riberalta end.

San Ramon - Trinidad The 367 Km. of this route are expected to be completed in 1982. Equipment for this work has been financed by CORDECRUZ, inasmuch as it is considered an extension of the Santa Cruz-Trinidad road.

Puerto Siles - San Joaquin - San Ramon The 84 Km. of this road are being constructed with much difficulty. Small and irregular budget allocations to this project cause frequent interruptions and hamper progress by SNC. In fiscal year 1979, there were no funds allocated to this project.

<u>Chimore</u> - <u>Yapacani</u> The engineering studies and final design of this route were completed in 1977. The total cost of this project has been estimated to be $107 million, one-fifth of which is to be financed from local sources and the remainder by the IBRD. The project consists of the construction of 102 Km. between the Ivivigarzama and Vibora rivers, improvement of 30 Km. of the existing road between the Ivivigarzama and Chimore rivers, improvement of 21 Km. of road between the Yapacani and Vibora rivers, and enlargement and protection of the bridge on the Chimore river. Construction was expected to start in June 1981, immediately after the rainy season.

<u>Projects under study or partially completed</u>

<u>Etemerazama river</u> - <u>Secure river</u> - <u>San Ignacio</u> This project is a component of the 540 Km. Cochabamba-Trinidad road, through Villa Tunari. As can be seen in Figure 9, the 180 Km. segment between the city of Cochabamba and the Etemerezama river has already been built. Likewise, the 88 Km. segment between Trinidad and San Ignacio is in operation. In relation to the 132 Km. between the Etemerezama and Secure rivers, a road is partially built up to a place named Moleto, 70 Km. northwest of the Etemerezama river. From the other end, approximately 13 Kms. have been built of the 140 Kms. stretch between San Ignacio and the Secure river. Progress in both ends has been slow due to decreasing budget allocations in recent years. Although the major part of this route has been a subject of study, there remains to be studied the 55 Kms. segment between the Ichoa and Secure rivers and the 40 Kms. between the Secure river

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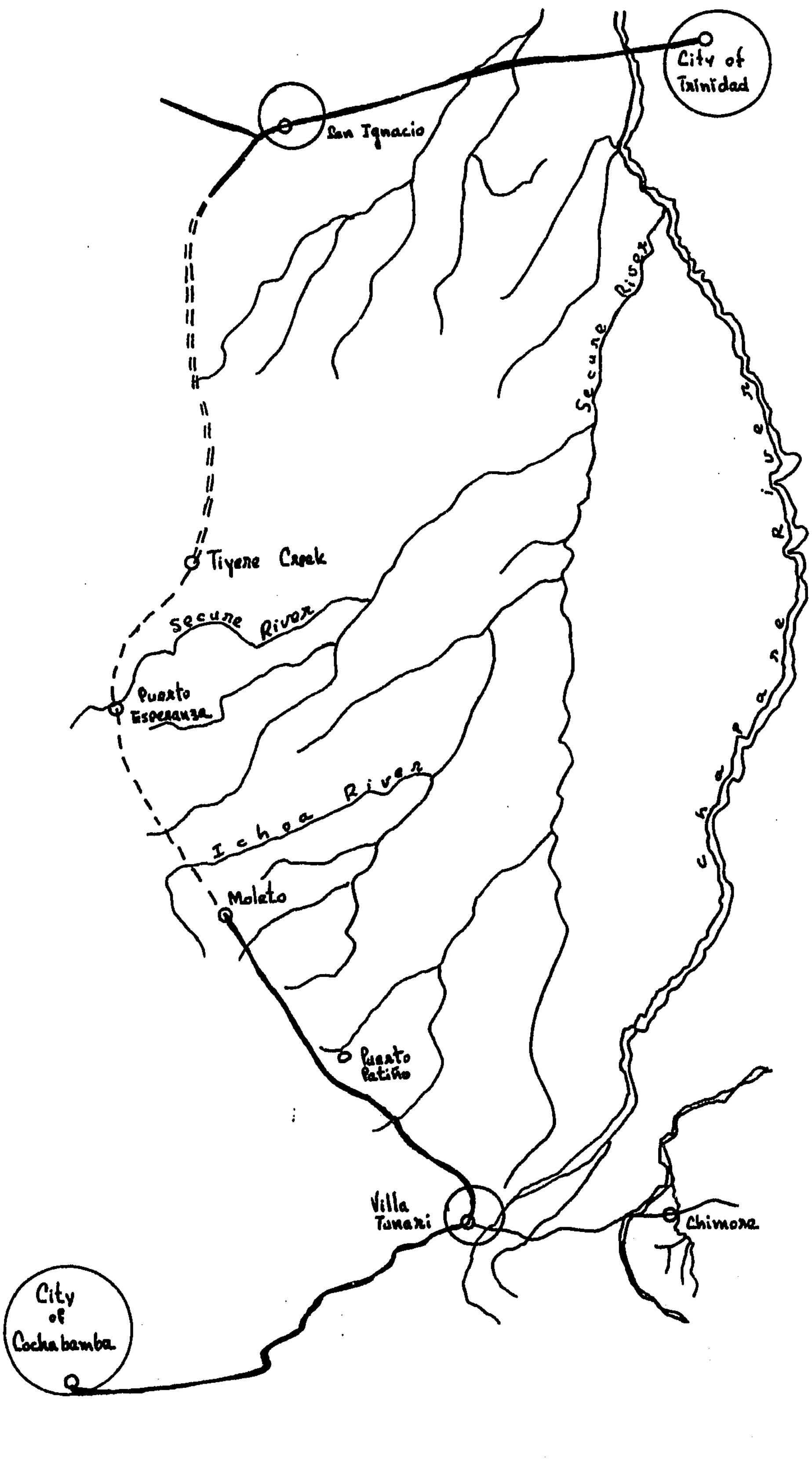
Figure 9. Cochabamba-Trinidad road



City of Trinidad
San Ignacio
Secure River
Tiyene Creek
Secure River
Puerto Esperanza
Ichoa River
Moleto
Puerto Patiño
Chapare River
Villa Tunari
Chimore
City of Cochabamba

and the Tiyere Creek.

Santa Cruz - Trinidad This connection is currently under study by CORDECRUZ. The road is expected to pass through the towns of Casarabe and Asuncion de Guarayos in Beni. If undertaken, this route will close a circuit between the cities of Santa Cruz, Cochabamba, and Trinidad.

Air transportation

This mode of transportation is especially important for certain routes and commodities. It plays a major role for the country's beef industry, inasmuch as all carcasses shipped from slaughterhouses in Beni are air-transported. This has been the case since the late 1940s, when planes were introduced.

Bolivia has approximately thirty airports in departmental capitals and some major provincial towns, which are served by the domestic trunk line (LAB). All of these airports can accommodate 30-40 passenger aircraft or small cargo planes. Only the airports of La Paz, Cochabamba, Santa Cruz, Trinidad, and Sucre can presently handle jet aircraft. With the exception of the Trinidad airport, all airports in Beni are presently unpaved. Additionally, there exist an estimated 500 airstrips, either military, private, or clandestine, where nonscheduled carriers operate.

Most airstrips in Beni cannot handle more than ten ton piston planes and dirt prevents the use of turboprop planes. There are 47 commercial airfields in Beni. However, the exact number and location of airfields in Beni is not known.

The supplemental carriers, which provide irregular air transportation services for passengers and cargo, operate in routes and regions not served by LAB. In many of these routes, the supplemental carriers constitute the sole mode available. Products such as beef, woods, Brazil nuts and rubber are flown from the lowlands to consumption centers in the highlands and valleys. However, the bulk of such traffic is composed of beef. The back haul cargo, from the highlands and valleys to the lowlands, involves products like sugar, rice, flour and alcohol.

Because planes must be paid for the incoming as well as the outgoing flight, only large cattlemen can afford contracting them. Hence, large cattlemen control the wholesale market and buy cattle from small and medium size producers. Planes depart from La Paz or Cochabamba, loading fuel for their return trip.

According to a report from the Bolivian government, in 1978, there were 21 supplemental carriers operating 47 aircraft of various types, of which only 32 were in working condition (MTCAC, 1978). JUNAC reports that 27 planes form the beef transportation fleet, with an aggregate cargo capacity of 150,500 Kgs. (April, 1978, p. 75). It must be noted that these beef carriers have an average age of 20 years.

Several problems afflict these carriers, decreasing their productivity and hampering their development. Due to usage, lack or high cost of spare parts, scarce financing available, and harsh operating conditions in Beni, the average number of flying hours per aircraft is low. It has been estimated that only 25 percent of the flying capacity was being employed at the time of the Hunting-Vivado study (1973, p. 253), that is, only 55 flying hours per month per plane, or approximately eighteen flights per month per plane.

Beef cattle are slaughtered in some 24 slaughterhouses in Beni, usually located near airstrips. Carcasses are usually loaded hot onto the floor of the aircraft to be transported to the cities of La Paz, Cochabamba, Oruro and to the COMIBOL mines. Transportation conditions are most inadequate, inasmuch as several airplane components are removed to increase payload capacity. Ventilation, air conditioning, insulation, cabin booths, floor and ceiling covers are all removed. Carcasses are then piled up on wooden platforms where they face a high risk of bacterial contamination.

With the exception of a handful of firms, most beef carriers in Bolivia have unstable operations, and are generally short lived due to low maintenance standards, insufficient equipment, and under-capitalization.

The Hunting and Vivado study (1973, p. 315), suggested the use of improved air transportation services from Beni to the beef consumption centers of the highlands and valleys of the country and abroad. This recommendation was reasonable given that in the early 1970s no significant changes in surface transportation relationships were expected.

<u>On foot transportation</u>

In Bolivia, as in the United States before the arrival of the railroad, on-foot transportation is the dominant mode for live cattle shipments. About 60 percent of the live cattle moved in Bolivia travel on foot. This is the cheapest transportation mode for livestock, if the animals are not harmed and have adequate over-night forage.

Cattle travel from Beni to Santa Cruz in three-to-four weeks. This traffic takes place only in the dry season. The main problems along the way are the lack of water and feed. These factors plus the fact that cattle are usually slaughtered without adequate rest cause heavy weight and quality losses.

A major part of the live cattle output of the Marban province in Beni is transported on foot to the city of Santa Cruz. The 210 Kms. trail from Loreto to Ascencion de Guarayos, plus the 240 Kms. from this locality to the city of Santa Cruz are preferred to the 54 Kms. journey from Loreto to Trinidad. Reasons for this occurrence can be found in better prices for cattle in the Santa Cruz market, family ties, and low cost of on-foot transportation (CNRA, 1976, p. 375). In recent years, as Bauer comments, this traffic has been diminished as high exit taxes of $b 150 and $b 100 per head of female and male cattle have been charged in Ascencion de Guarayos to benefit the University of Beni (BAB, 1970, p. 12).

The Santa Cruz and Chaco regions are more fortunate than Beni, for they have year-round transportation surface exits for their live cattle exports. Cattle cannot be driven out of Beni during the rainy season because of flooding and dangerous river crossings.

The city of Santa Cruz is the natural center for live cattle flows incoming from the eastern and southern parts of the Santa Cruz department. From Santa Cruz there is an important traffic of live cattle to Cochabamba, through Vallegrande. In the department of Santa Cruz, most cattlemen drive their cattle on foot to the city of Santa Cruz, where it is slaughtered or shipped to Cochabamba.

CHAPTER V. PROBLEM FORMULATION

Bolivia's beef-cattle industry

Although having a great production potential, the Bolivian beef-cattle industry is considered by most observers to be primitive in the extreme. This condition is a reflection of the country's low level of development, inadequate transportation infrastructure and inconsistent government policies.

Meat handling operations in Bolivia, as in most LDCs, are characterized by primitive production methods, atomization of activities, lack of refrigerating facilities, inadequate transportation services, low sanitary and hygienic conditions, lack of veterinary inspection, slaughter of unfinished stock, and absence of incentives for improved quality production.

Price controls During the last two decades, the Bolivian government has followed a policy of providing cheap beef to the urban population. In this context, price ceilings on beef have been established to ensure beef supplies to lower income households. Maximum wholesale beef prices at the national level are fixed by the Ministry of Industry, Commerce and Tourism, while the municipalities fix maximum retail beef prices in their jurisdictions. Although official price ceilings are uniform for all cuts, in practice, the best cuts command premium black market prices from high income consumers. Low income consumers, on the other hand, pay official prices for a mixture of beef, fat, and bones.

Low beef prices have encouraged consumption of the product and reduced consumption of other meats. In this manner, beef has become an increasingly important component of the diet of the urban population. However, because cheap beef policies do not reach the rural consumer, and urban consumers have low incomes, the animal protein intake of the Bolivian population as a whole is still low.

Due to the fact that the country's international borders are extensive and the government lacks the necessary manpower and resources for adequate control, price ceilings on beef have prompted large numbers of cattle to be illegally exported to neighboring nations such as Brazil and Peru. Artificially low beef prices, which tend to remain nominally fixed over long periods of time, reduce investment flows and the profitability of the cattle industry. Because cattle growers cannot increase the price of their product, many have been forced to increase slaughter rates, oftentimes reducing their breeding stock, so as to meet loan payments and rising production costs.

In general, producers have adjusted to the beef price ceilings by providing a product of low quality which does not satisfy most sanitary and hygienic requirements. As a consequence, Bolivian beef is currently banned in several markets, being occasionally exported only to northern Chile.

Even though most studies have noted the negative consequences that result from beef price ceilings, the Bolivian government has shown itself unable or unwilling to remove them. One of the principal beneficiaries of the price controls on beef is the state mining corporation (COMIBOL), which has in beef one of the principal components of its salary compensation program. Price ceilings on beef also provide a political instrument to the government as they contribute to dampen cost of living increases in urban areas.

The cattle grower associations of Beni and Santa Cruz, the most important private entities of the Bolivian cattle industry, have learned to live with the price ceilings. Time after time, these organizations engage in negotiations with the government to achieve increases in the price ceiling level, export quotas, or other compensatory arrangements.

Because of the damaging effects that result from the price controls on beef, and the difficulty of their removal, it is generally agreed that this conflict is the toughest issue facing the Bolivian beef-cattle industry.

The transportation infrastructure   The lack of an adequate transportation network has also limited the development of the cattle industry in the Bolivian tropics. Until air transportation services were introduced in 1947, there was not a competitive mode to ship live cattle nor beef from the lowlands to consumption centers in the rest of the country. In the early 1950s, the Cochabamba-Santa Cruz highway was completed, becoming the first year-round surface linkage between the Santa Cruz lowlands and the highlands and valleys of Bolivia.

Figure 10 shows the surface and waterway transportation infrastructure that existed by 1980, as well as the principal cattle growing regions in the country. More than one-half of Bolivia's cattle population is located in the department of Beni, in the tropical lowlands. Presently, there are few surface and waterway outlets for live cattle in Beni. There exist cattle trails connecting certain regions in Beni with the departments of Santa Cruz and La Paz, and with Brazil. These trails generally lack feeding and watering facilities, and present numerous natural obstacles along the way.

One outlet for live cattle from Beni that has gained importance in recent years involves a combination of river barge and trucking. This bimodal linkage connects vast areas in Beni, in the area of influence of Mamore River, with the city of Cochabamba. River transportation along Mamore River also permits a dense downstream flow of cattle to Brazilian markets.

Because of transportation inadequacies, the bulk of Beni's cattle output is currently shipped by air to consumption centers in the highlands and valleys of Bolivia.

Strategy for development In the last fifteen years, several studies of the Bolivian cattle-beef industry have been conducted to aid the government in formulating a development strategy. These studies have all recommended that economic incentives be created to foster productivity increases and improved processing conditions. Establishment of price differentials for quality has

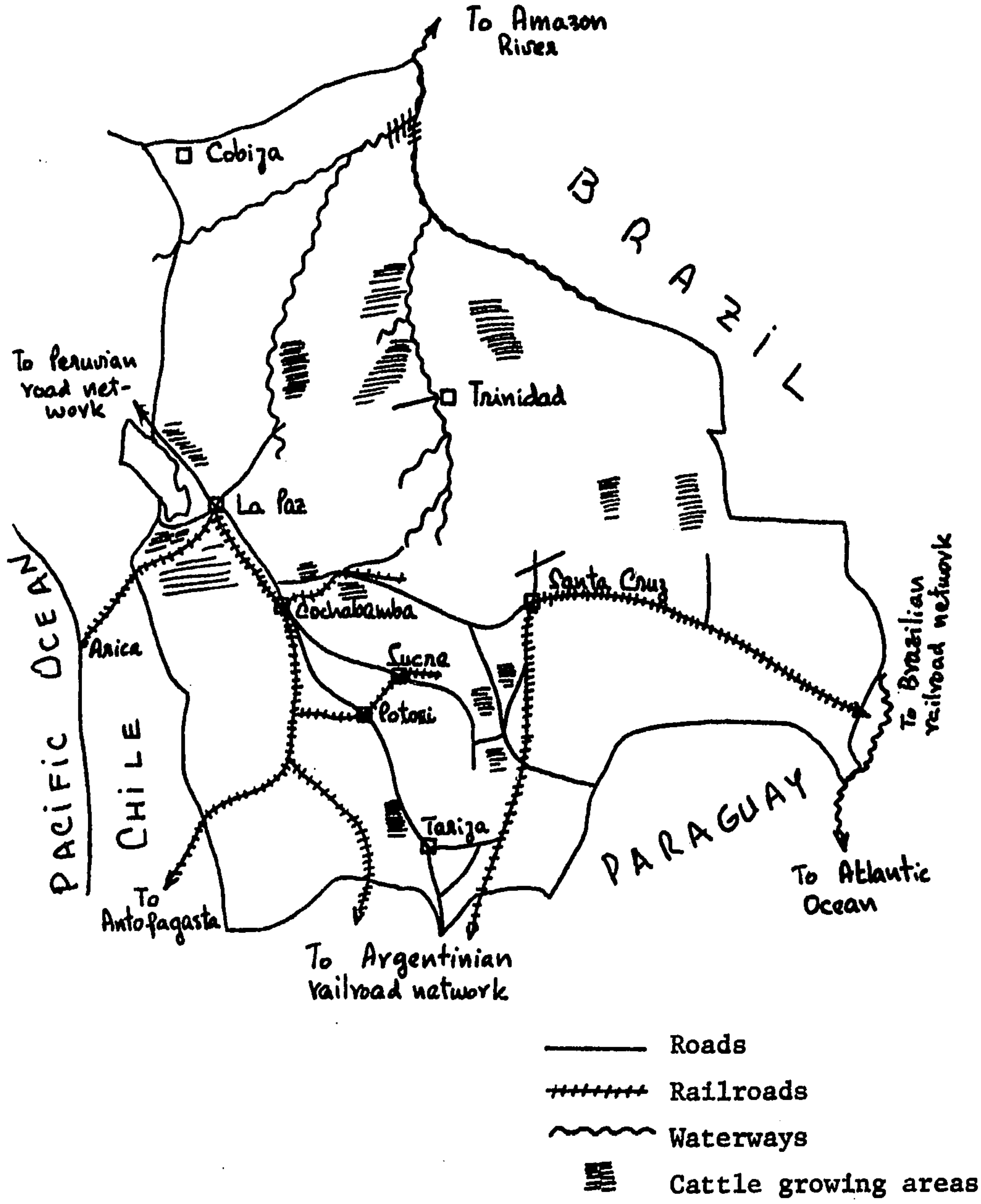


Figure 10. Bolivia: existing transportation infrastructure (roads, railroads, waterways) - 1980

been considered essential to rationalize consumption, encourage investment into the industry, reduce illegal exports and penetrate foreign markets. Allowing the prices of the higher quality cuts to increase is expected to boost industry profitability and simultaneously maintain or even decrease prices of lower quality cuts to benefit lower income groups.

Achieving quality price differentials and producing high quality cuts under proper veterinary inspection, hygienic and sanitary conditions requires the establishment of adequate slaughter and processing facilities. These facilities may be provided by modifying existing structures or constructing new ones. In deciding where to construct new processing facilities, or which existing facilities to modify, valuable insights can be obtained from plant location analysis.

The relevance of location theory

As its name suggests, the theory of location studies the places where economic activities are or ought to be located. Location analysis is necessary because productive factors are not perfectly mobile, there exist costs of transportation, alternative sites have different properties, and supply-demand conditions vary with time. In the case of fixed production facilities (e.g., airports or slaughterhouses) location mistakes can be costly, because once put into place the cost of moving these facilities is extremely high.

Different economic activities compete for the space available in a given economic region. Location patterns are a result of such competition. These patterns have a definite effect upon all economic relationships taking place in a given region and in interdependent regions.

Location decisions can be studied from a microeconomic or a macroeconomic standpoint. For the firm location decisions involve the selection of the best location in relation to its markets, input sources, infrastructure facilities, type of production processes, characteristics of the output, public regulations and incentives, and environmental factors. From the viewpoint of the economy as a whole, location theory is concerned with the location, concentration, and dispersion of whole industries; the location of cities and different economic activities within them; the location of development places or growth centers, etc.

In earlier times, location decisions were constrained by the topographical and geographical features of the terrain (i.e., availability of river transportation, mountain passes, etc.). Sites were chosen by trial and error (i.e., the Jesuit settlements in Beni in the 17th and 18th centuries). This is an acceptable method when the amount of resources committed is relatively small, or when societies are rich enough to afford the waste associated with location mistakes. However, in present times, because most nations on earth face serious scarcity of resources and face strong development pressures, there is an increasing need for careful location of economic activities.

Government action can have a significant impact upon location patterns. This occurs mainly through legislation (e.g., zoning); taxes and subsidies (e.g., funds from the general revenue are used to cover operating losses of railroads); trade barriers such as production quotas, tariffs, sanitary regulations, etc.; and the provision of infrastructure (electricity, roads, water, etc.).

Cost considerations play a critical role in most location decisions, and especially those associated with processing and transportation. Processing costs can be broken down into those that are related to labor and those that are not. Among the principal nonlabor processing costs that affect location decisions, we can cite land rents, interest rates and insurance premiums, of which the most important are the former. In considering labor costs, aspects such as the minimum level of wages, productivity, turnover and attitudes, skills, the supply function, laws, and the extent and character of unionism in the area need to be considered. Labor costs are most important when production processes require large numbers of workers (e.g., textiles and shoe production). This explains why in the later stages of the product life cycle, sites are selected in areas or countries where labor is abundant and cheap.

Generally, wages at a given location are related to food, clothing, housing, and transportation costs. Migration tends to equalize wages by inducing the displacement of individuals from labor-rich areas to labor-poor ones. Regions which are depressed or densely populated, and hence have lower wage levels, usually experience high rates of migration.

Transportation costs play a fundamental role in site selection, especially when they differ significantly among alternative sites; they differ between the raw material and the finished product (e.g., cattle and beef); they constitute a large portion of the final product value; the product is perishable, and needs quick delivery and/or service; and the raw materials are characterized by weight losing properties (e.g., livestock).

Location of slaughterhouses in Bolivia

Various locational patterns, plant sizes and designs have been suggested by the Hunting-Vivado consultants and a FAO/World Bank commission. A JUNAC report has recently recommended that a national slaughterhouse plan be formulated. The Hunting-Vivado study recommended the construction or rehabilitation of eight type "A" slaughterhouses (five in Beni, and one in each of the cities of La Paz, Cochabamba, and Santa Cruz) and fourteen type "B" slaughterhouses (nine in the departments of Santa Cruz, Beni, and Tarija and five in the departments of Oruro, Potosi, Sucre, and Tarija).[1] The FAO/World Bank mission which visited the country in 1978 suggested the construction of eight new slaughterhouses (in the Alto Beni and Chapare regions, and in the cities of La Paz, Cochabamba, Oruro, Santa Cruz, Tarija, and Trinidad), rehabilitation of one slaughterhouse

[1]Type "A" plants were to have complete hygienic and sanitary facilities, while type "B" plants were expected to meet a set of minimum hygienic norms.

in the city of Santa Cruz and equipment of another located in the city of Sucre.

Locational patterns of slaughterhouses must be analyzed in light of the country's changing transportation relationships. In the course of the present decade, several important transportation projects are expected to be completed, as a result of the national commitment to integrate the country. As is shown in Figure 11, the department of Beni, its capital city Trinidad, and several important cattle growing areas in the department occupy a key position in the future transportation network. In the next few years, Trinidad is to be linked by road transportation with the cities of La Paz, Cochabamba, and Cobija, and with the towns of Riberalta, San Joaquin and Baures. Other linkages involving waterway, railroad, and road transportation are to be completed to connect Trinidad with the city of Santa Cruz.

Completion of these transportation linkages will undoubtedly have a major impact upon the entire Bolivian economy and society. The beef-cattle industry in Beni, however, will be one of the most directly affected. This is due to the fact that the new transportation projects will penetrate regions with significant potential for cattle growing activities. By altering the relative competitiveness of each cattle producing region, the new transport connections will cause major changes in live cattle and beef flows throughout the country.

The Hunting-Vivado study, completed in 1973, did not foresee most of these transportation changes scheduled to occur in the 1980s. The

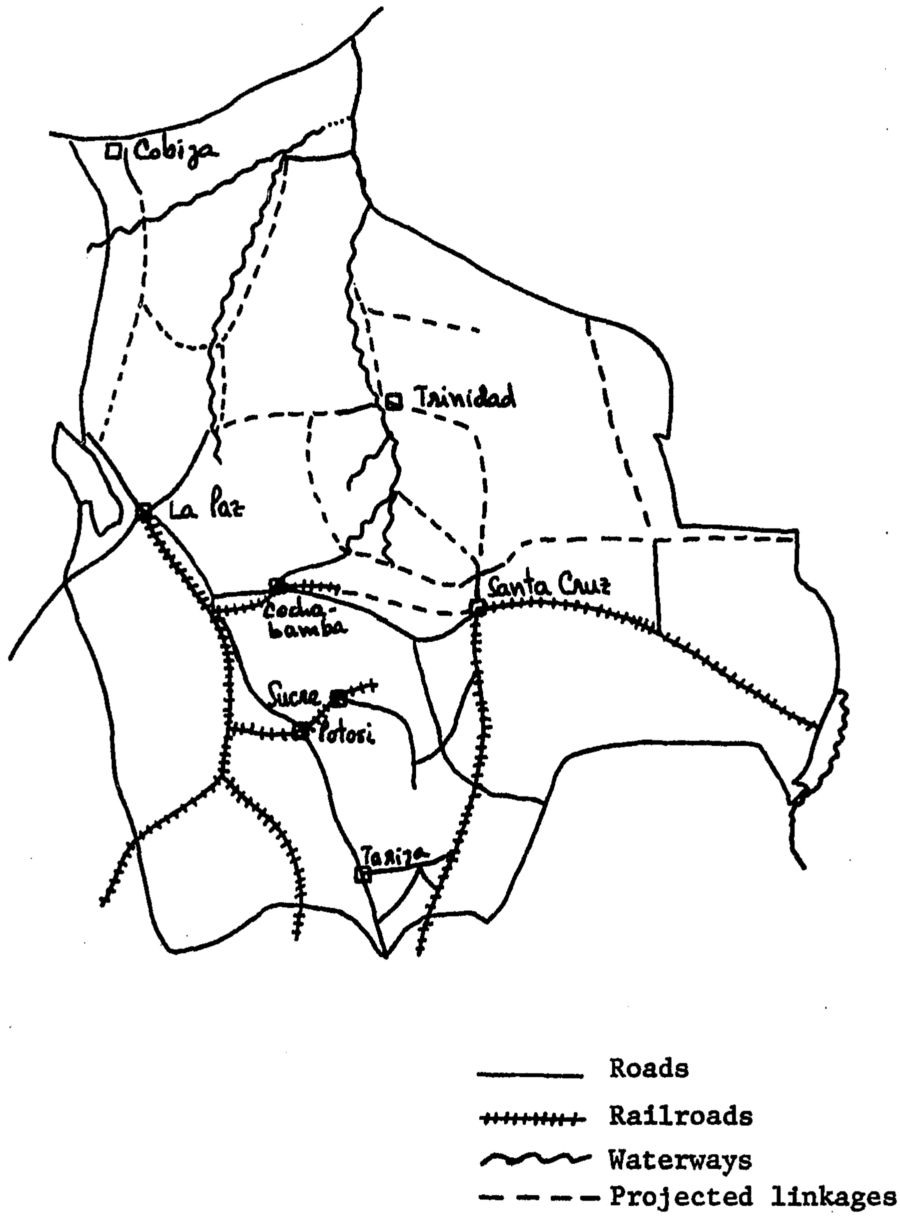


Figure 11. Bolivia: existing and projected transportation infrastructure (roads, railroads, and waterways)

FAO-World Bank mission did consider only two transportation projects (the road connecting the city of La Paz with Trinidad, and the river barge-truck connection between Trinidad and the city of Cochabamba). Moreover, the commission conditioned its slaughterhouse location pattern to the results of two location feasibility studies in the Alto Beni and Chapare regions, to be conducted subsequently.

These two location studies still remain to be done, as does the national slaughterhouse plan recommended by JUNAC.

This dissertation is devoted to an analysis of the effects that some of the transportation projects expected to be completed in the course of the 1980s will have upon the Beni beef-cattle industry. Specifically, I intend to determine the impact that the transportation facilities expected to exist at the end of the 1980s will have upon the optimal patterns of slaughterhouse location in the department of Beni and upon the optimal flows of cattle and beef from Beni to other regions in the country and to neighboring nations.

The present research is relevant inasmuch as it will provide a procedure upon which a national slaughterhouse plan may be subsequently formulated. It will also serve to examine the optimality of the slaughterhouse location patterns recommended by the Hunting-Vivado consultants and the FAO-World Bank mission for the department of Beni.

CHAPTER VI. ANALYTICAL PROCEDURE

Allocation and location models

Allocation and location models occupy an important place in economic analysis. Allocation models, also known as "interregional competition" or "spatial equilibrium" models, permit to determine the most desirable factor or commodity flows between supply and demand areas, so as to make the best use of existing production facilities. Allocation models may be of three types: factor-factor, product-product, or factor-product, depending on whether the items being transported are factors of production or final products, and on whether these items are transformed.

An allocation analysis of livestock and meat (factor-product) was undertaken by Rizek, Judge and Havlicek (1965). These authors developed a model to determine the regional levels of slaughter, and the directions and levels of interregional flows of livestock and meat, satisfying regional production, consumption and slaughter capacity constraints, and minimizing the total costs of transportation and processing. The general linear programming approach used by these authors allows the assessment of the impacts of alternative regional slaughter capacity restrictions upon optimal factor-product flows and regional levels of slaughter.

These authors assumed the existence of various regions with known (≥ 0) quantities of each type of livestock in different periods of time. Each unit of livestock, as it passes through a slaughterhouse is converted into meat. Dressing percentages are known for each region, time period, and type of livestock. Each region has a known, positive, slaughter capacity in each time period. Demands for each type of meat and transport costs for livestock and meat are all known.

Location models are an aid in determining the best uses of new production facilities. When both existing and new production facilities and/or additional capacity are being considered, location-allocation models need to be employed.

One of the best known plant location models was formulated by John F. Stollsteimer (1963). His model seeks to determine the number, size, and locations of plants to be built, the amounts to be processed in each plant, and the amounts to be shipped from each origin to each plant to minimize total assembly and processing costs of raw material. His model assumes that there are not existing plants, and can be employed only when the location of new facilities is being considered. Stollsteimer's model can be applied to different scenarios, depending on what assumptions are made with respect to economies of scale and plant costs at different locations.

Sanders and Fletcher (1966) made use of the Stollsteimer model in their study of the optimum marketing organization of the Iowa egg industry. They sought to determine the number, size and location of egg processing plants that minimized the combined costs of assembling and processing eggs under alternative production patterns. These researchers were not concerned solely with the optimum number, size and location of plants but they sought to determine the effects of various factors (such as truck size, production patterns of flocks, and size of flocks) upon assembly costs. Likewise, the sensitivity of the optimal location pattern to changes in various factors which affect assembly, processing and distribution costs was explored.

Ladd and Halvorson (1969) also made use of the Stollsteimer model in their study of turkey processing in Minnesota, Iowa, and Wisconsin. Having hypothesized that the costs of assembly and processing turkeys in these states would decrease with fewer plants, they sought to determine the number, size, and location of turkey processing plants that would process turkeys grown in the three states at minimum assembly and processing cost. Their analytical procedure consisted in identifying various sources of supply, determining the amount of raw material available at each origin, selecting possible plant sites, computing costs of hauling raw materials from each source to each plant site, and determining the costs of processing various volumes at each plant site.

Transshipment models

Stollsteimer's model is useful in location studies in which the costs of transporting goods in or out of a plant, but not both, are considered. When transportation costs into and out of the plant need to be considered, transshipment plant-warehouse models need to be used. Given J plant sites, H raw material sources, and I markets, transshipment models permit to determine the number, location, size of plants, sources and markets for each plant, so as to minimize assembly, processing and distribution costs.

Ladd and Lifferth (1970) developed a location-allocation model which considered the utilization of existing facilities and the location of new facilities simultaneously. Their model, which is an extension of Stollsteimer's, sought to determine the heuristic optimal number, size, and location of new subterminal elevators, expansion in storage capacity of existing country elevators, the rail network, and the monthly flows of grain, from origins to elevators to destinations, to maximize the joint net revenue of corn and soybean producers in a 6 1/2 county region around Fort Dodge, Iowa.

A problem of similar nature was solved by Hilger, McCarl and Uhrig (1977). These authors analyzed the total annual cost of grain (corn and soybeans) movement from 124 origins in northwest Indiana through a number of country and subterminal elevators, to thirteen destinations, so as to determine optimal subterminal elevator locations. The 19 potential subterminal sites were the locations of 4 existing subterminals, 9 country elevators considered likely candidates for expansion, 2 sites under consideration by grain companies, and 4 sites chosen by the researchers based upon grain density. The analytical procedure used by these authors involved mixed integer programming with Benders decomposition. This is an iterative technique in which the mixed variable programming problem is decomposed into two separate ones, global optimality being attained through the use of dual information.

King and Logan (1964) made use of the transshipment model of linear programming developed by Kriebel (1961), to determine the optimum location of processing plants (slaughterhouses) and shipment patterns of raw materials (live cattle) and final products (beef) in California. Their analytical procedure consisted in assigning to each region a value for average processing costs associated with a large processing plant operating at capacity, that is, the lowest possible costs for each region. Then a minimum cost solution was found, involving a volume of processing using all possible locations. The processing costs assigned for each plant location were then compared with the costs of a plant size just sufficient to process the volume indicated by the minimum cost solution. Processing costs were then adjusted and a minimum cost solution recalculated.

King and Logan (1964) assumed that the decisionmaker was a single product firm. Existing slaughter facilities were not considered in the analysis. It was also assumed that an unrestricted amount of raw material (cattle) can be processed in any one region. Additional assumptions specified that cattle supplies and beef demands were given in all regions; transport costs of cattle and beef were given and did not vary with quantity shipped; and slaughter costs per animal varied with plant size and region.

In King and Logan's (1964) analysis, live cattle and beef shipments, and volumes of slaughter cattle at each location are variable. In any given iteration, processing costs are fixed, but may vary among iterations.

Hurt and Tramel (1965) suggested an alternative formulation of the

King and Logan procedure. Hurt and Tramel's model is applicable to conditions where processing capacity in any one or all of the regions is limited, but where the total processing capacity is more than enough to handle all raw materials. Moreover, the model permits consideration of problems involving multiple regions, plants, processing stages, and products.

Hurt and Tramel assumed that supplies of raw materials and final product demands were fixed in all regions. Likewise, all average transport and average processing costs were taken as given. By allowing for limited processing capacity in all regions, this model permits consideration of existing plants, in addition to new processing capacity.

In his study of the interregional competitive position of the hog-pork industry in the southeastern region of the United States, Rhody (1963) used the method of reduced matrices for the simultaneous consideration of flows of primary products through processing facilities to the market as final products. He assumed that the supply of hogs, slaughter capacity, and pork demand in each area, as well as the transport costs between origins, intermediate points, and destinations are all known. A dummy hog supply and pork demand area were included to compensate for excess hog slaughter capacity.

Procedure selected

The criterion of optimality selected in this analysis is the minimum combined costs of (a) transporting cattle from producing regions in Beni to slaughterhouses in Beni and to live cattle markets elsewhere in Bolivia and in neighboring countries; (b) processing cattle at slaughterhouses in Beni; and (c) transporting beef to consumption centers elsewhere in the country and abroad.

Figure 12 presents more clearly the problem under consideration. Cattle produced in a given region may be exported live or slaughtered and then exported. Two types of slaughter facilities, "H" and "L", to serve high and low quality beef demand, are considered.

At the present time, about sixty type "L" slaughterhouses exist in the department of Beni. It is doubtful that new ones would have to be built. These low quality, rudimentary, beef processing plants serve the domestic market and occasionally the northern Chilean market.

Type "H" slaughterhouses are modern facilities, not yet in existence in the country. These are to be built so as to satisfy minimum beef processing hygienic requirements. Their output is to be directed to foreign markets (Chile, Brazil, and Peru) and to higher income consumers in the cities of La Paz, Cochabamba, Trinidad and Santa Cruz. The analytical procedure to be used in the problem under consideration is a modified version of the procedures developed by King and Logan (1964) and Rizek, Judge and Havlicek (1965). This is so because two beef qualities, produced in two distinct types of slaughterhouses, are considered.

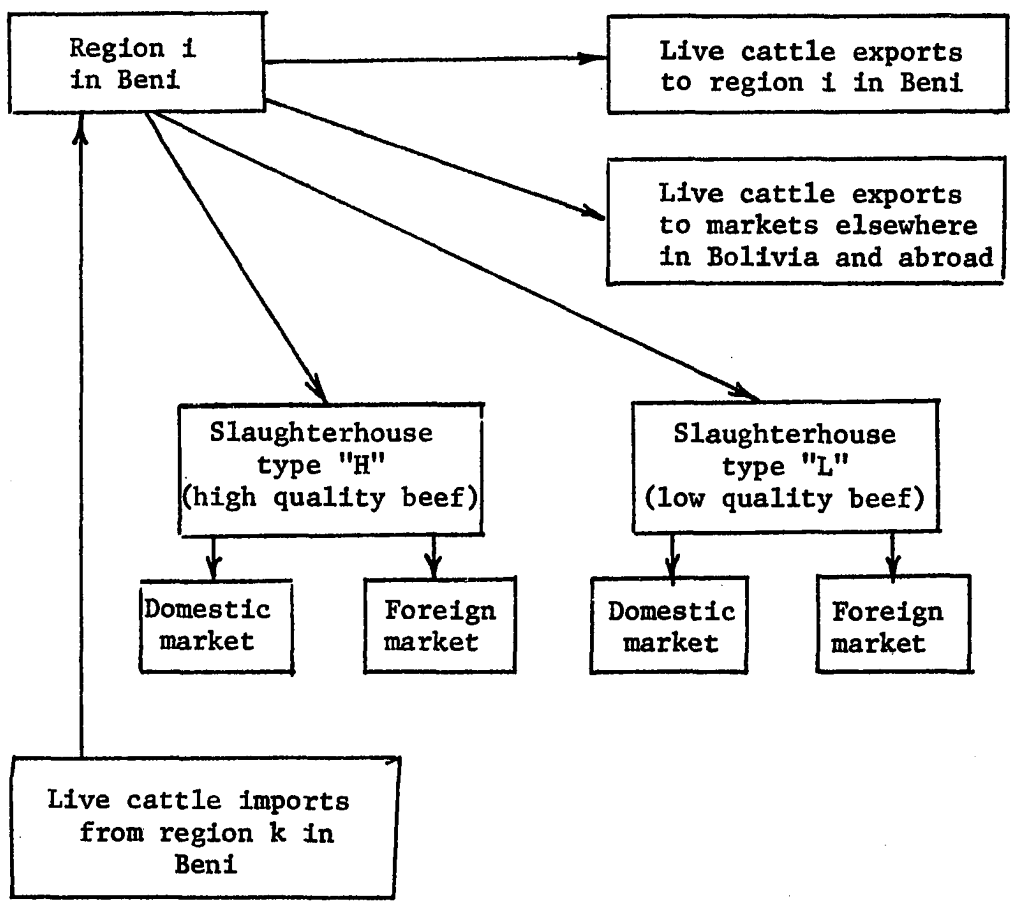


Figure 12. Raw material and final product flows

Moreover, all slaughterhouses of type "L" are in existence, while none exist of type "H". Consequently, the model must provide insights into the optimal use of the existing type "L" plants, location and use of type "H" plants, and factor-product flows.

Assumptions

In order to formulate the analytical procedure in a mathematical form, it is necessary to state the following assumptions:

- There is only one homogeneous type of cattle, the supply of which in each region is known with certainty and is infinitely inelastic.
- There are two types of slaughter facilities: type "H" (modern-not yet in existence) and type "L" (rudimentary-existent-with known capacity).
- Both types of plants use the same raw material, but turn out different beef qualities: type "H" beef (high quality) or type "L" beef (low quality).
- Dressing percentages do not vary by region nor by type of plant.
- There exists a well differentiated demand for each type of beef in each region, which is known with certainty and is infinitely inelastic.
- Transfer costs for live cattle and for type "H" and "L" beef among regions for different transportation scenarios are all known. The cost of each shipment is proportional to the amount shipped, the total transfer cost being equal to the sum of individual costs.

Notation

Let:

i, j denote the regions ($i, j=1, 2, 3, \ldots, n$);

X_{ij} denote the quantity of type "H" beef shipped from region i to region j;

Y_{ij} denote the quantity of type "L" beef shipped from region i to region j;

CH_{ij} denote the beef equivalent of live cattle shipped from region i to region j, and then converted into "H" quality beef;

CL_{ij} denote the beef equivalent of live cattle shipped from region i to region j, and then converted into "L" quality beef;

P_i denote the quantity of type "H" beef produced in region i;

Q_i denote the quantity of type "L" beef produced in region i;

T_{ij} denote the transport cost of type "H" beef from region i to region j;

U_{ij} denote the transport cost of type "L" beef from region i to region j;

t_{ij} denote transport cost of the beef equivalent of live cattle from region i to region j;

a_i denote the average total slaughter cost for type "H" beef in region i;

b_i denote the average variable slaughter cost for type "L" beef in region i;

S_i denote the supply of live cattle in region i;

D_i denote the quantity demanded of type "H" beef in region i;

E_i denote the quantity demanded of type "L" beef in region i;

r_i denote the slaughter capacity for type "L" beef in region i;

h_i denote the slaughter capacity for type "H" beef in region i.

Mathematical model

Minimize:

(1) $$Z = \sum_{ij}\sum T_{ij} \cdot X_{ij} + \sum_{ij}\sum U_{ij} \cdot Y_{ij} + \sum_{i} a_i \cdot P_i$$

$$+ \sum_{i} b_i \cdot Q_i + \sum_{ij}\sum t_{ij} \cdot (CH_{ij} + CL_{ij})$$

(total costs of beef shipments, slaughter of cattle, and live cattle shipments).

Subject to:

(2) $$\sum_{j} X_{ij} = P_i$$

(the quantity of type H beef shipped from the ith region equals the beef equivalent of animals slaughtered in type H plants in region i).

(3) $$\sum_{j} Y_{ij} = Q_i$$

(the quantity of type L beef shipped from the ith region equals the beef equivalent of animals slaughtered in type L plants in region i).

(4) $$- P_i - Q_i + \sum_{j} (CH_{ij} - CH_{ji} + CL_{ij} - CL_{ji}) \geq - S_i$$

(the numbers of cattle slaughtered in type H and L plants, adjusted for in and outshipments of live cattle, must be equal to or less than the ith region's supply of live cattle).

(5) $$\sum_{j} X_{ji} = D_i$$

(total availability of type H beef - including own production and inshipment - equals the demand for type H beef in region i).

(6) $$\sum_{j} Y_{ji} = E_i$$

(total availability of type L beef - including own production and inshipments - equals the demand for type L beef in region i).

(7) $- P_i \geq - h_i$

(the number of animals processed in type H plants is smaller than or equal to the regional slaughter capacity).

(8) $- Q_i \geq - r_i$

(the number of animals processed in type L plants is smaller than or equal to the regional slaughter capacity).

(9) $X_{ij}, Y_{ij}, P_i, Q_i, CH_{ij}, CL_{ij} \geq 0$

(all choice variables must assume nonnegative values).

The linear program presented above is shown in tabular form in table 9. The body of this table is occupied by transfer coefficients.

The system (1) through (9) denotes the primal problem, which has five sets of choice variables and seven sets of constraint equations. Consequently, the corresponding dual problem has five sets of constraint equations and seven sets of choice variables, and in standard form can be expressed as:

Maximize:

(10) $$W = \sum_i (0) \lambda_{i1} + \sum_i (0) \lambda_{i2} - \sum_i S_i \lambda_{i3} + \sum_i D_i \lambda_{i4} + \sum_i E_i \lambda_{i5} - \sum_i h_i \lambda_{i6} - \sum_i r_i \lambda_{i7}$$

Table 9. Programming table for a two region example

	Type "H" beef flows				Type "L" beef flows			
Row name	X_{11}	X_{12}	X_{21}	X_{22}	Y_{11}	Y_{12}	Y_{21}	Y_{22}
COSTS	T_{11}	T_{12}	T_{21}	T_{22}	U_{11}	U_{12}	U_{21}	U_{22}
HIG 1	1		1					
HIG 2		1		1				
LOW 1					1		1	
LOW 2						1		1
CAT 1								
CAT 2								
DEH 1	1		1					
DEH 2		1		1				
DEL 1					1		1	
DEL 2						1		1
SLH 1								
SLH 2								
SL 1								
SL 2								

Proc. Activities: H beef		Proc. Activities: L beef		Live cattle flows							
P_1	P_2	Q_1	Q_2	CH_{12}	CH_{21}	CL_{12}	CL_{21}				
a_1	a_2	b_1	b_2	t_{12}	t_{21}	t_{12}	t_{21}				
-1								=	0	Type "H"	Aggregate demand/ processing eqs.
	-1							=	0		
		-1						=	0	Type "L"	
			-1					=	0		
-1		-1		-1	1	-1	1	≥	$-S_1$	Live cattle supplies	
	-1		-1	1	-1	1	-1	≥	$-S_2$		
								=	D_1	Type "H" beef demand	
								=	D_2		
								=	E_1	Type "L" beef demand	
								=	E_2		
-1								≥	$-h_1$	Type "H"	Slaughter capacities
	-1							≥	$-h_2$		
		-1						≥	$-r_1$	Type "L"	
			-1					≥	$-r_2$		

(Interpreting the λ_{ij}'s as internal prices and rents, then W can be considered as the aggregate returns to the slaughter cattle and slaughterhouse owners).

Subject to:

(11) $\lambda_{i1} - \lambda_{j4} \leq - T_{ij}$

(If λ_{i1} is interpreted as the value of type H beef in region i and λ_{j4} is its value in region j, then the difference of these values must be smaller than or equal to the negative of the transport cost from i to j. This is equivalent to $\lambda_{j4} - \lambda_{i1} \leq T_{ij}$, that is, the price differential between two regions has to be smaller or equal to the cost of transportation between them. If $X_{ij} > 0$, then $\lambda_{i1} - \lambda_{j4} = - T_{ij}$; and if $X_{ij} = 0$, then $\lambda_{i1} - \lambda_{j4} \leq - T_{ij}$).

(12) $\lambda_{i2} - \lambda_{j5} \leq - U_{ij}$

(In similar form as the previous one, this equation applies to type L beef).

(13) $\lambda_{i3} + \lambda_{i6} - \lambda_{i1} \leq - a_i$

(Considering λ_{i3} to be the value of slaughter cattle in region i; λ_{i6} the internal rent that may accrue to a type H slaughterhouse in region i; and λ_{i1} the value of beef in region 1; then it is necessary that the value of beef be greater or equal to the value of slaughter cattle plus the cost of slaughter plus the internal rent of the slaughterhouse in region i).

(14) $\lambda_{i3} + \lambda_{i7} - \lambda_{i2} \leq - b_i$

(In similar form as the previous one, this equation applies to type L beef).

(15) $\lambda_{i4} - \lambda_{j4} \leq - t_{ij}$

(Interpreting λ_{i4} and λ_{j4} as the value of slaughter cattle in regions i and j, respectively, then the difference between these values has to be greater than or equal to the cost of transporting live cattle between the two regions. If CH_{ij} or CL_{ij} are greater than zero, then $\lambda_{i4} - \lambda_{j4} = - t_{ij}^{ij}$).

(16) λ_{i3}; λ_{i6}; and $\lambda_{i7} \geq 0$

λ_{i1}; λ_{i2}; λ_{i4}; and λ_{i5} unrestricted in sign.

<u>Application</u> To measure the effect of the new transport projects upon plant location patterns and factor-product flows, using the previously outlined linear programming framework, two sets of transport costs will be employed. One set of transport costs will correspond to the 1980 transport infrastructure (figure 10). The other set will consider the new transport connections which are expected to be completed by the year 1990 (figure 11). Specifically, the following new linkages will be included:

Roads: La Paz - Trinidad
La Paz - Riberalta
Cochabamba - Trinidad
Santa Cruz - Trinidad
Cochabamba - Santa Cruz
San Ramon - Trinidad

Railroads: Santa Cruz - Rio Mamore
Cochabamba - Santa Cruz

In addition, four different type H beef export scenarios have been conceived, namely:

A - All exports are directed to region 16 (Arica, Chile).

B - All exports are directed to region 17 (Lima, Peru).

C - All exports are directed to region 18 (Guagara-Merim, Brazil).

D - Equal export volumes are directed to regions 16, 17, and 18.

Optimal plant location patterns will then be found for every one of these export alternatives, using both sets of factor-product transport costs. In this manner, it will be possible to assess the impact of the new transport linkages upon optimal plant location arrangements and factor-product flows in Beni.

Given a set of transport costs, and one export scenario, optimal plant location patterns and factor-product flows will be determined in the following manner. Initially, every suitable region will be assigned the maximum possible processing capacity and its corresponding processing costs. Subsequently, employing the King-Logan iterative procedure, selected locations will be adjusted in their processing capacities and associated costs according to the slaughter levels indicated in the preceding program run. This process will be continued until a consistent minimum cost solution is found, in which the optimal plant locations, processing volumes, sizes, and factor-product flows are determined. A solution is considered to be consistent when, for every plant included in it, the size and level of operation correspond to the cost of processing.

CHAPTER VII. DATA COMPONENTS

The Beni area

The department of Beni and the approximate locations of its cattle ranches are shown in Figure 13. Beni is partitioned into eight provinces and its capital is the city of Trinidad. In 1980, the human population of Beni was around 200,000. Surface area has been estimated at 213,564 Km^2 (21,356,400 Has.) almost one-fifth of the Bolivian territory and twice the size of Germany.

Livestock production constitutes the main economic activity of the region. It is estimated that the department hosts more than 3,200 cattle ranches of varying sizes. The owners of many of these ranches are among the more affluent segment of the country's population.

Clayburn and the CNRA study have estimated the average animal carrying capacity of land in Beni to be .30 head of cattle per Ha., (BAB, 1970, p. 3 and CNRA, 1976, p. 252). The larger ranches of the department tend to have lower cattle-land ratios (.20) than the smaller ranches (.56 head per Ha.). Animal carrying capacity of land is lowest in Mamore province (.16) and highest in Marban province (.31 head per Ha.) (CNRA, 1976, p. 252).

The larger ranches of Beni have lower human population densities (.29/Km^2). Population density is greatest in the peasant communities of the department (20.94/Km^2).

According to a recent CNRA study, the distribution of natural

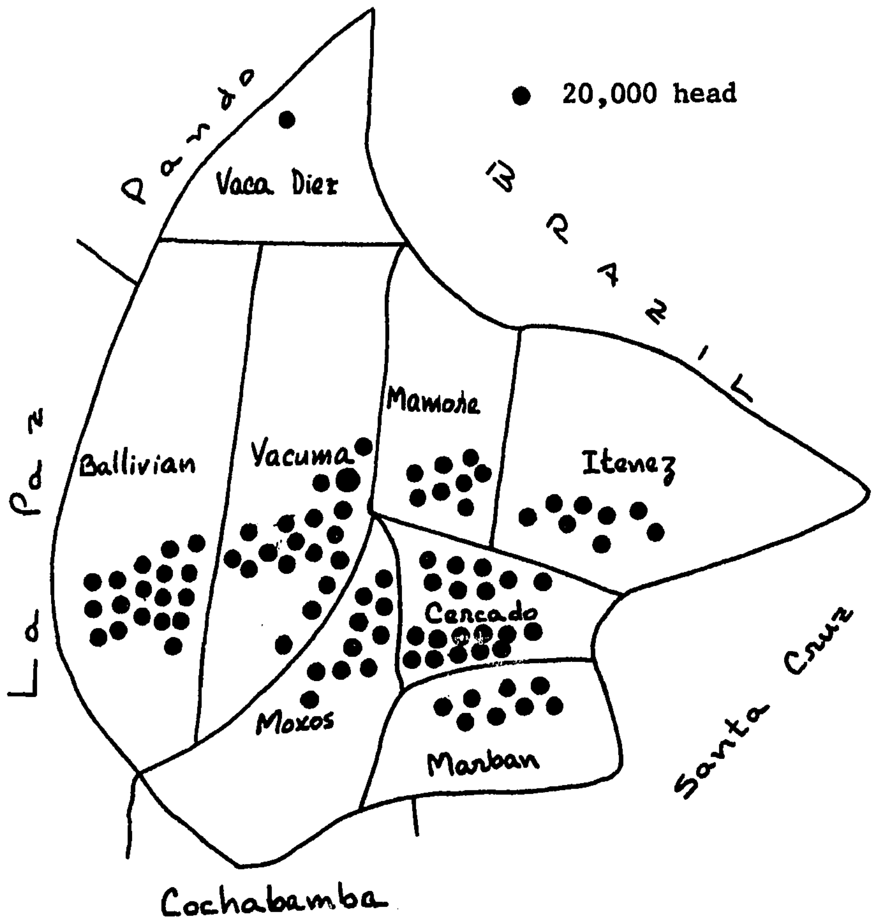


Figure 13. Beni: provinces and distribution of its cattle ranches

resources in Beni is unequal, inasmuch as the large cattle growers own the bulk of the cattle and the land, as well as the best sites with easier access and closest to the population centers. It appears that in the Bolivian lowlands the Agrarian Reform benefited only a handful of individuals (CNRA, 1976, p. 125). Fifteen percent of the cattlemen in Beni own 85 percent of the cattle (CODEBENI, 1980, p. 51).

The Agrarian Reform law for tropical and subtropical regions in Bolivia established three ranch sizes: small, having up to 500 Has. of land; medium, having from 501 to 2,500 Has.; and large, having from 2,501 to 50,000 Has. Although the upper limit on land area of any ranch in Beni is 50,000 Has., there exists evidence of multiple holdings that bypass the law.

Topography varies among the different provinces in Beni. The Ballivian, Yacuma and Moxos provinces present a flat landscape with occasional waves, with the exception of Rurrenabaque and part of the Reyes area, which are located at the foot of the El Bala, El Pilon, and the Khara-Khara mountains.

In the flatlands, seasonal flooding of varying duration occurs during the rainy season. In the most flood-prone lands, permanent bodies of water are formed. Some of these bodies of water have surface vegetation and receive the name of Yomomales, while others that do not have such vegetation are known as curiches. Both of these are a source of water during the dry season, from June to November.

In Beni, use of pastures is seasonal. During the rainy season, cattle feed in natural or artificial high grounds, oftentimes with water reaching their mid-bodies. Flooding from February to May reduces the range of pasture land and forage species.

Regional partition

To analyze the problem under consideration, the department of Beni was partitioned in twelve regions, as is shown in Figure 14. Regions 1, 2, 3, 4, and 5 correspond to the provinces of the same names. Ballivian province was broken down into regions 6, 7 and 8. Yacuma province was divided into regions 9 and 10. Moxos province was partitioned into regions 11 and 12. Each one of these regions corresponds or is contained entirely within one province.

Six live cattle and beef market regions outside of Beni were selected. Region 13 groups the cities of La Paz and Oruro, and the Comibol minefields. Inclusion of these consumer centers into one single destination (La Paz) is appropriate because of the 225 Km paved road linking La Paz and Oruro, and the fact that Oruro is one of the principal unloading points for Beni beef air carriers supplying the mining corporation. Regions 14 and 15 represent the cities of Cochabamba and Santa Cruz, respectively. Regions 16, 17 and 18 stand for destinations in Chile, Peru, and Brazil, in that order.

Even though it was possible to conduct a more detailed, although not necessarily better, regional partition, it was decided to consider only 18 regions. This was so because computation costs

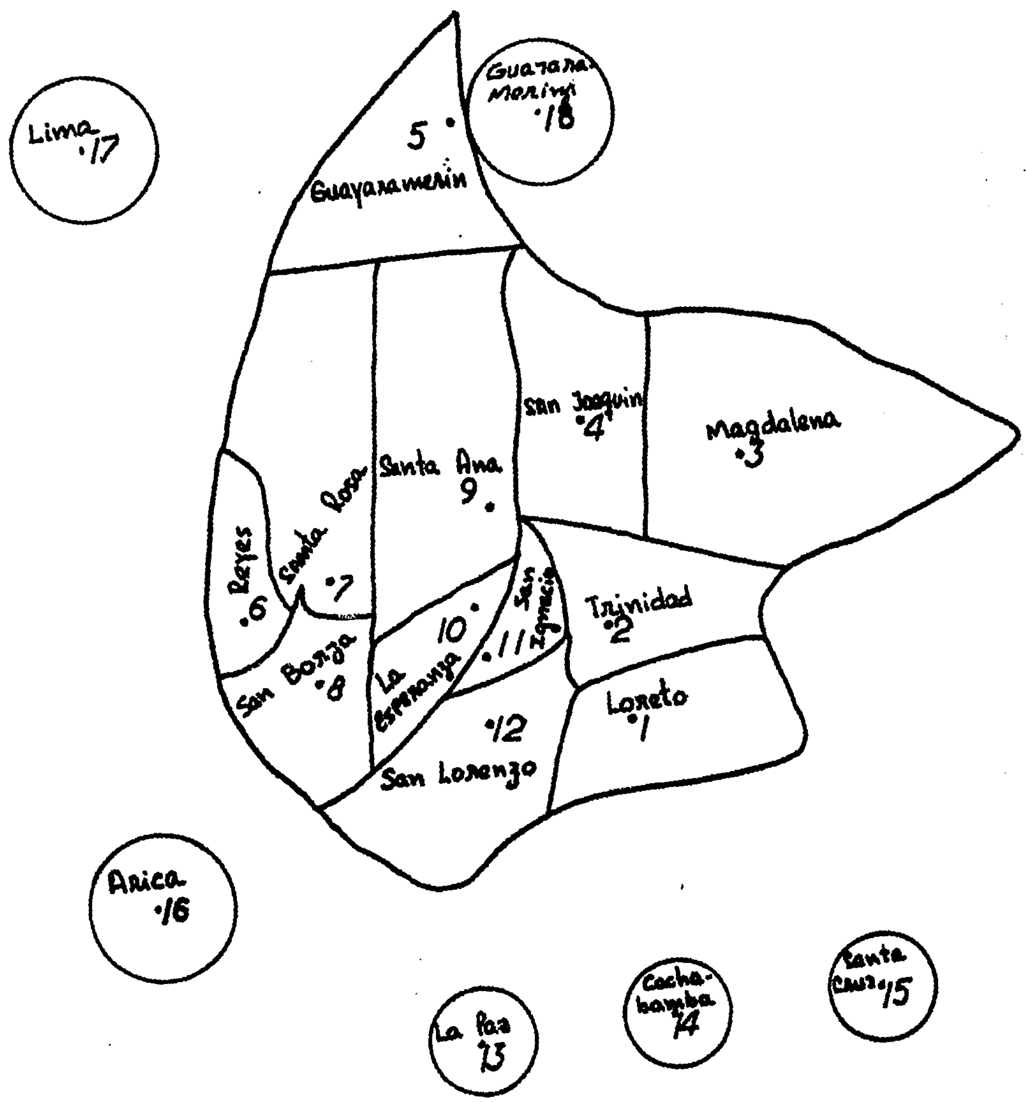


Figure 14. Regional partition and "central points".

increase rapidly as the number of regions grows larger. As formulated, the 18-region linear programming matrix has 1,297 columns and 127 rows. Were the number of regions increased to 20, the matrix would increase in size to 1,601 columns and 141 rows. For a 28-region problem, the programming matrix would have 3,083 columns and 197 rows.

Furthermore, as the number of regions is increased, especially when provinces are partitioned, reliable information becomes harder to find, inasmuch as most data is published for provinces. It will be observed later in this chapter, that much difficulty was encountered in determining parameter values for regions 6 through 12, each of which represents an area within a province.

One "central point" was selected in each one of the 18 regions. It is assumed that all cattle growing and slaughter operations as well as final product demands are located at these points. The localities selected in each region are presented in Table 10.

Table 10. Regional central points

Region	Locality	Region	Locality
1	Town of Loreto	10	Ranch La Esperanza
2	City of Trinidad	11	Town of Sn. Ignacio
3	Town of Magdalena	12	Town of Sn. Lorenzo
4	Town of Sn. Joaquin	13	City of La Paz
5	Town of Guayaramerin	14	City of Cochabamba
6	Town of Reyes	15	City of Santa Cruz
7	Town of Sta. Rosa	16	City of Arica, Chile
8	Town of Sn. Borja	17	City of Lima, Peru
9	Town of Sta. Ana	18	Town of Guayara-Merim, Brazil

Figure 14 shows also the location of the selected "central points". These locations, in Beni, have been positioned in the sites considered to have major economical importance in relation to cattle-beef production activities. In most cases, the "central" locations selected also enjoy the status of provincial or cantonal administrative centers. In relation to the nonBeni regions within Bolivia (13, 14 and 15), because of their importance as consuming centers, the cities of La Paz, Cochabamba and Santa Cruz were selected as the "central" locations-destinations of the highlands, valleys and Santa Cruz areas, respectively. Finally, the foreign destinations have been centered in the cities of Arica, Chile (region 16), Lima, Peru (region 17), and the town of Guajara-Merim, Brazil (region 18).

Supplies of slaughter cattle

More than one-half of Bolivia's cattle population is located in the department of Beni. Jointly, the departments of Beni and Santa Cruz possess three quarters of the national herd, as is shown in Table 11. Annual output figures in table 11 were obtained assuming a 13 percent extraction rate (that is, the percentage of the total cattle herd slaughtered and marketed as beef in a given period). Hunting and Vivado (1973, p. 4), have estimated a maximum extraction rate of 13.5 percent for the year 1972, and of 11 percent for a stabilized cattle population. The FAO-WB study assumed a 13.4 percent off-take rate for 1977 (1978). This same study assumed national production of beef to grow at a yearly rate of 3 percent until 1996,

Table 11. Bolivia: cattle population and output by departments (1980)[a]

Department	Number of head	Percent	Annual output
La Paz	264,040	6.61	34,325
Cochabamba	84,952	2.13	11,044
Santa Cruz	778,344	19.49	101,184
Chuquisaca	352,436	8.82	45,817
Oruro	122,836	3.08	15,969
Potosi	34,440	.86	4,477
Tarija	89,544	2.24	11,641
Beni	2,245,000	56.20	291,850
Pando	22,960	.57	2,985
Total	3,994,552	100.00	519,292

[a]Sources: JUNAC, April 1978, p. 51; FAO-WB, 1978; and OEA-CODEBENI, 1980.

and expected carcass weight to increase from 182 to 200 kilograms, mostly due to improved trucking and grading (FAO-WB, 1978, p. 4).

There was no problem in obtaining cattle population estimates for regions 1, 2, 3, 4, and 5 in Beni inasmuch as each one of them represents a province. However, there was no information available concerning cattle populations of regions 6, 7, 8, 9, 10, 11 and 12 which are contained in the Ballivian, Yacuma and Moxos provinces. Unfortunately, in Bolivia there is not adequate information concerning the cattle population and yearly beef output of each region. Available data are usually aggregated by provinces, little being known about less important geopolitical units. Information concerning interprovincial live cattle flows is practically nonexistent. These defficiencies result mainly from the lack of a national livestock census and the nonexistence of an adequate information system.

To remedy the lack of data pinpointing the location of cattle herds in specific areas of the Ballivian, Yacuma and Moxos provinces (regions 6 through 12) the findings of a study conducted by Manuel Vivado in 1965 were employed. In this study, the locations of the larger (more than one-hundred head) ranch headquarters were indicated by numbered dots. In a separate listing, the name of the ranch and its owner, as well as the herd size, corresponding to each dot are provided. The ranches and their corresponding herds, falling within each of the regions in the Ballivian, Yacuma, and Moxos provinces were then aggregated. This procedure permitted to estimate the cattle population of each one of the regions in these provinces as of 1965. With these approximations, it was then possible to obtain the share of each province's cattle population corresponding to each region. Such estimated shares are the following: 13, 55, and 32 percent for regions 6, 7, and 8, respectively, in Ballivian province; 80 and 20 percent for regions 9 and 10, respectively, in Yacuma province; and 67 and 33 percent for regions 11 and 12, respectively, in Moxos province. These regional shares of provincial cattle numbers were subsequently applied to the more recent (1979) and authoritative (OEA-CODEBENI) estimates of cattle populations for each province.

Once regional cattle populations were estimated, a 13 percent extraction rate was assumed for all regions to obtain annual cattle outputs. Estimates of cattle outputs corresponding to the years 1980 and 1990 were obtained assuming an annual 3.5 percent herd growth rate for all regions. Table 12 shows projected cattle outputs for 1980 and 1990. It is assumed that the average carcass weight will increase in this period from 170 to 200 Kgs.

Given that no significant cattle nor beef imports from Chile, Peru, nor Brazil currently take place, that none are expected in the future, and that there exists a positive demand for cattle and beef from Bolivia in these three countries, no supplies of cattle have been considered in any of them. Consequently, regions 16, 17, and 18 have zero cattle supplies and they will be solely importers of Bolivian live cattle and/or beef.

Consumption of cattle and beef

Table 13 shows the quantities of beef consumed in the principal markets of the country. The city of La Paz is clearly the most important beef market. Per capita consumption of beef, however, is larger in Beni and among COMIBOL employees. Beef consumption per capita in the city of La Paz is relatively smaller because there is greater availability of other types of meat, which are oftentimes easier to market in Bolivia (i.e., pork and lamb).

Average annual meat consumption in urban areas is estimated to be around 30 Kgs. per capita, of which approximately one-half is beef. There exist in Bolivia substantial differences in beef consumption, according to regional and income classifications. One survey conducted in the city of La Paz in the mid-1960s revealed that

Table 12. Regional cattle outputs[a]

Region	Name	Share of province's cattle (%)	Cattle population (no. of head 1979)	Cattle output-1979 (no. of head)
1	Marban	100	307,000	39,910
2	Cercado	100	326,000	42,380
3	Itenez	100	300,000	39,000
4	Mamore	100	314,000	40,819
5	Vaca Diez	100	47,000	6,110
6	Reyes	13	41,600	5,408
7	Sta. Rosa	55	176,000	22,880
8	Sn. Borja	32	102,400	13,312
9	Sta. Ana	80	252,800	32,864
10	La Esperanza	20	63,200	8,216
11	Sn. Ignacio	67	211,050	27,437
12	Sn. Lorenzo	33	103,950	13,514
	Sub-total Beni regions		2,245,000	291,850
13	Highlands		429,038	55,775
14	Cochabamba		280,262	36,434
15	Sta. Cruz		512,746	66,657
	Sub-total Bolivian regions		3,467,046	450,716
16	Chile		0	0
17	Peru		0	0
18	Brazil		0	0

[a]Sources: Vivado, Manuel, 1966, pp. 1-19.
OEA, 1980.
FAO/World Bank, 1978.
JUNAC, 1978, Bolivia Produccion, Comercializacion, p. 5.

[b]170 Kgs. carcass weight.

[c]200 Kgs. carcass weight.

Cattle output-1980		Cattle output-1990	
No. of head	Kgs.[b]	No. of head	Kgs.[c]
41,307	7,022,190	58,325	11,665,000
43,863	7,456,710	61,935	12,387,000
40,365	6,862,050	56,995	11,399,000
42,248	7,182,160	59,654	11,930,800
6,324	1,075,080	8,929	1,785,800
5,597	951,490	7,903	1,580,600
23,681	4,025,770	33,438	6,687,600
13,778	2,342,260	19,455	3,891,000
34,014	5,782,380	48,028	9,605,600
8,504	1,445,680	12,008	2,401,600
28,397	4,827,490	40,096	8,019,200
13,987	2,377,790	19,750	3,950,000
302,065	51,351,050	426,516	85,303,200
57,727	9,813,590	81,510	16,302,000
37,709	6,410,530	53,245	10,649,000
68,990	11,728,300	97,414	19,482,800
466,491	79,303,470	658,685	131,737,000
0	0	0	0
0	0	0	0
0	0	0	0

Table 13. Beef consumption in the principal markets (MT)[a]

Market	1976	1977	1978	1979
La Paz	14,707	15,730	16,800	17,900
Cochabamba	5,713	6,110	6,500	6,900
Santa Cruz	10,878	12,020	13,200	14,500
Beni	9,717	10,070	10,400	10,750
COMIBOL	7,548	7,640	7,730	7,830
Oruro	1,660	1,720	1,780	1,840
Total	50,223	53,290	56,410	59,720

[a]Sources: JUNAC, 1978, p. 55-8; OEA and CODEBENI, 1980, p. 25.

59 percent of household consumption expenditures were for food. A little more than 16 percent of expenditures on food corresponded to meat and fish. Beef represented 48 percent of all the meat consumed (Hunting and Vivado, 1973, p. 98). The high share of income spent on food reflects the predominance of low income consumers. It is the predominance of low income consumers that explains why in Bolivia the demand for low priced meat is so important.

In the principal beef markets of the country there is a relatively small demand for high quality cuts which command higher prices. The bulk of the internal demand for beef is for low quality cuts. Moreover, the consumption of red and white offal represents an important part of the diet of the lower income groups. With the exception of horns and blood, practically no slaughter output is lost. This situation explains the high prices paid for offal in all markets in the country.

In rural areas of the country, beef consumption is estimated to be from nine to ten kilograms per capita per year (FAO and WB, 1978, p. i).

Income elasticities of demand for beef were obtained in a survey carried on in 1972. These elasticities were equal to .738 for rural zones, .56 for provincial cities, and .32 in the city of La Paz (LeBaron, 1977, p. 8). The low income elasticity of demand for beef in the capital city of La Paz is explained by consumption having reached a saturation point. Vanderlice was surprised by the high percentage of income allocated to meat and the low income elasticity of demand for meat in La Paz. He found that people with incomes between $300 and $400 were allocating up to 50 percent of them to meat purchases (BAB, Anexo J, 1970, p. 73).

Because of the circumstances described above, it is expected that consumption of meat in the major urban areas will not increase as rapidly as income levels. The greatest potential for increased meat consumption lies in rural migration to the cities, where urban consumption patterns are adopted.

The key factor influencing beef consumption in the country appears to be the rate of population growth. In 1976, 43 percent of the population lived in urban areas. The FAO-WB mission has estimated that by 1996, 46 percent of Bolivia's seven million people will live in eight major urban centers (1978, p. 5). Population has been increasing at a rate of 2.14 percent per year, while the urban population has been experiencing a 3.3 percent annual growth. These trends led the FAO-WB consultants to expect a 4 percent annual increase in private consumption expenditures and a 5.2 percent annual increase in urban areas, for the period 1976-1996. Total demand for meat is expected to increase at an annual rate of 3.5 percent (1978, p. 12). L. Vanderlice also established this rate of growth by assuming a 3.25 percent annual increase in population, a 1 percent annual income growth rate, and a .25 percent income elasticity of demand for beef (BAB, 1970, p. 74).

COMIBOL, the state mining enterprise, is one of the most important beef consumers in the country. It has around 25,000 employees, who with their families form a population of around 120,000 persons. These employees and their families receive subsidized beef, rice, flour, and milk, in addition to various social services to compensate for their low salaries. Coupons for these products are issued on a quota basis, purchases being discounted from monthly wages. Employees receive a seventeen kilogram per month quota of low quality beef for a four to five member family. Quota sizes vary according to family size.

COMIBOL purchases about 130,000 kilograms of beef per week, that is, 47,000 head of cattle per year, which represents about 11 percent of total national beef consumption. Retail prices of beef sold to employees vary in different mines, but average \$b 2.80 per kilogram. JUNAC (1978, p. 62) has estimated the net subsidy paid by COMIBOL in \$b 18.55 per kilogram.

To handle its beef purchases, an entire set of facilities has been established by COMIBOL. The facilities include airfields, trucks, cold stores and distribution warehouses. Beef deliveries are made at specific airfields from which the product is distributed to the various mines.

To estimate regional demands for cattle and beef, use was made of human population data for each province in Beni and for the three other non-Beni regions within Bolivia. Population estimates of Beni in 1980 were obtained from CODEBENI projections. Provincial shares of departmental population were determined from data reported by CNRA in 1976. To remedy the lack of population information for regions 6 through 12, the land area of each one of these regions was estimated. Assuming the human population in each province to be evenly distributed, the land area share of each province accounted by each region was multiplied by the aggregate provincial population. Land areas, in Km^2, for regions 6 through 12 were estimated to be 10,111; 18,199.8; 12,133.2; 24,070.2; 10,315.8; 15,127.2; and 18,488.8, respectively.

With the exception of region 2, where the urban area of Trinidad represents a major component of the total population, and where human population is expected to grow at a yearly rate of 3.7 percent, human populations in Beni regions are assumed to grow at an annual rate of 3.5 percent (FAO/WB, 1978, p. 9). Population in the cities of La Paz, Cochabamba, Santa Cruz, Oruro and in the COMIBOL minefields is estimated to grow at a yearly rate of 3.5, 3.95, 6.67, 2.93 and

2.10, respectively (FAO/WB, 1978).

Beef consumption estimates were obtained multiplying human population figures by per capita consumption estimates for each region within Bolivia. For all regions in Beni, an annual per capita beef consumption of 58 Kgs. was used (CODEBENI, 1980, p. 28). This estimate was expected to remain unchanged in 1990. In the case of region 13, the following yearly per capita beef consumption estimates were employed: city of La Paz, 21.9 Kgs; city of Oruro, 16.1 Kgs.; and COMIBOL mines, 55 Kgs, for the year 1980 (FAO/WB, 1978, p. 6). For 1990, per capita consumption of beef in the cities of La Paz and Oruro was expected to increase to 22.6 and 16.7 Kgs, based upon FAO/WB projections (FAO/WB, 1978). Per capita consumption levels of COMIBOL employees were expected to remain unchanged in 1990. Consumption figures for the cities of Cochabamba and Santa Cruz were assumed to be 36 and 43.1 Kgs. of beef per capita in 1990, based upon the same FAO/WB projections used to estimate per capita consumption figures for La Paz and Oruro. Because FAO/WB consumption projections were elaborated for the years 1986 and 1996, the midpoint of these projections was taken to correspond to the year 1990.

In Table 14 are shown the estimated regional human populations and beef consumption levels for 1980 and 1990. With the exception of region 2, all regions in Beni are assumed to demand only low quality beef. Consumption shares of high quality beef in regions 2, 13, 14, and 15 have been arbitrarily set at 20 percent of total beef consumption.

Table 14. Regional cattle-beef consumption[a]

Region		Human population 1980	Beef consumption 1980		Human population 1990
			No./head	Kgs.	
1	Marban	9,575	3,267	55,350	13,520
2	Cercado	24,893	8,493	1,443,794	35,826
3	Itenez	36,382	12,413	2,110,156	51,371
4	Mamore	22,978	7,839	1,332,724	32,445
5	Vaca Diez	22,978	7,839	1,332,724	32,445
6	Reyes	6,702	2,286	388,716	9,463
7	Sta. Rosa	12,064	4,116	699,712	17,034
8	Sn. Borja	8,042	2,744	466,436	11,355
9	Sta. Ana	20,221	6,899	1,172,818	28,552
10	La Esperanza	2,757	941	159,906	3,893
11	Sn. Ignacio	16,678	5,690	967,324	23,549
12	Sn. Lorenzo	8,215	2,803	476,470	11,600
	Subtotal Beni regions	191,485	65,330	11,106,130	271,053
13	Highlands	1,026,293	153,315	26,063,550	1,414,005
14	Cochabamba	239,401	49,852	8,474,840	352,686
15	Sta. Cruz	332,701	83,371	14,173,070	635,100
	Subtotal Bolivia regions	1,789,880	351,868	59,817,590	2,672,844

[a]Sources: FAO/World Bank, 1978; CODEBENI, 1980; CNRA, 1976; and JUNAC, 1978.

[b]Note: To estimate the number of animals to be slaughtered in 1990, a 200 Kg. carcass weight has been assumed.

Beef consumption - 1990

Total No./head	Total Kgs.	Type "L" No./head	Type "L" Kgs.	Type "H" No./head	Type "H" Kgs.
3,921	784,200	3,921	784,200	0	0
10,389	2,077,800	8,311	1,662,200	2,078	415,600
14,898	2,979,600	14,898	2,979,600	0	0
9,409	1,881,800	9,409	1,881,800	0	0
9,409	1,881,800	9,409	1,881,800	0	0
2,744	548,800	2,744	548,800	0	0
4,940	988,000	4,940	988,000	0	0
3,293	658,600	3,293	658,600	0	0
8,280	1,656,000	8,280	1,656,000	0	0
1,129	225,800	1,129	225,800	0	0
6,829	1,365,800	6,829	1,365,800	0	0
3,364	672,800	3,364	672,800	0	0
78,605	15,721,000	76,527	15,305,400	2,078	415,600
182,304	36,460,800	145,843	29,168,600	36,461	7,292,200
64,187	12,837,800	51,351	10,270,200	12,838	2,567,600
137,817	27,563,400	110,254	22,050,800	27,563	5,512,600
462,915	92,583,000	383,975	76,795,000	78,940	15,788,000

Foreign demand for Bolivian cattle and beef

In Table 15 are shown the trade positions of Bolivia, Brazil, Chile and Peru. Note that all these countries, with the exception of Bolivia, are net importers of cattle and beef. Brazil constitutes the major importer by far; her yearly needs being several times larger than the Bolivian production surplus. However, in this table, Bolivian exports and Peruvian imports of live cattle are grossly underestimated. Statistics of CODEBENI indicate that in 1978, for example, 40,000 head were exported to Brazil through Guajara-Merim (Departamento Tecnico Estadistico Regional Beni, Julio de 1979). JUNAC has estimated that from 60,000-80,000 head of cattle are exported annually from Bolivian sources in North Altiplano to Peru and from Beni and eastern Santa Cruz to Brazil (JUNAC, 1978, p. 28). It must be kept in mind that these estimates can deviate significantly from reality due to the large numbers of cattle being exported undetected from sources within Bolivia.

The Peruvian market Beef is considered the most important meat in Peru, and this is increasingly so. Average meat consumption per capita in Peru was 26.3 Kgs. in the early 1970s (Kurian, 1979, p. 259). In the late 1960s, average meat consumption per capita was 19 Kgs. per year in Peru and 47 Kgs. in Lima, the capital city (Furnish, 1967, p. 1). These consumption volumes are among the lowest of the Americas. Peruvian meat demand has been estimated to be increasing at a rate of 4.2 percent per year (Shepherd and Furnish, 1968, p. 3).

Table 15. Imports and exports of bovine cattle and beef[a]

Country		Imports 1976	Imports 1977	Imports 1978	Exports 1976	Exports 1977	Exports 1978
Bovine cattle:							
Bolivia	(no. head)	16,400	16,800	17,000	48,000	38,000	40,000
	($1000)	2,000	2,300	2,600	8,900	7,000	7,700
Brazil	(no. head)	115,668	97,874	131,071	104,435	104,563	102,500
	($1000)	44,532	33,117	33,407	37,600	39,000	41,000
Chile	(no. head)	5,000	10,163	1,352	-	300	-
	($1000)	3,200	4,529	700	-	110	-
Peru	(no. head)	1,160	1,500	2,280	-	-	-
	($1000)	734	900	1,100	-	-	-
Beef:							
Bolivia	(MT)	-	-	-	-	130	-
	($1000)	-	-	-	-	169	-
Brazil	(MT)	22,647	25,696	112,605	11,544	31,246	9,600
	($1000)	16,113	22,438	93,410	16,022	39,561	17,155
Chile	(MT)	-	3,335	13,500	-	-	-
	($1000)	-	4,534	20,000	-	-	-
Peru	(MT)	5,232	3,000	1,500	-	-	-
	($1000)	3,874	2,700	1,500	-	-	-

[a]Source: FAO Trade Yearbook, Vol. 32, 1979, p. 45, 55.

Beef marketing in Peru is controlled by the government. Product prices are usually set at unrealistically low levels to favor the urban consumers, who on the average spend 26 percent of their incomes on meat (Agreement Ministry of Agriculture, et al. 1973, p. 103). In Lima, the wholesale price of beef is virtually fixed by the activity of the Frigorifico Nacional (national cold chamber), while the municipality establishes the maximum markup on meat retailing. In the cities outside Lima, municipalities set both wholesale and retail prices, and retailers are allowed up to 30 percent markups on perishable food items.

As in Bolivia, the better quality cuts are likely to command premium prices, well above the price ceilings, in the retail market. Meat quality at official prices is low. It is the understanding of Furnish that:

> "apparently (the authorities) are satisfied so long as the public is guaranteed the right to buy a kilo of "meat" (even if it is more than half bone and fat) at the specific top price"(1967, p. 41).

Most imported meat is received and consumed in Lima, the most important market in Peru, and the only place where appropriate slaughtering, freezing and refrigerating equipment exists. The Frigorifico Nacional (national cold chamber) at the seaport of El Callao is the checkpoint for all livestock imports for immediate consumption. This is the only processing plant for all imported animals, which are slaughtered in order of arrival. The state is responsible for all meat imports, through EPSA (Public Enterprise for Agricultural Services), which are almost totally destined to the department of Lima. Imported meat, classified as prime grade, is distributed to retail outlets to be sold mixed with other lower grade meats, with the same profit margins as those established for domestic prime grade beef (Agreement Ministry of Agriculture, et al. 1973, p. 64).

Meat importers require licenses. It is the government's practice to refuse licenses to control imports. Since 1966, the annual meat demand is forecasted so as to regulate monthly imports. The country imports a large percentage of her meat needs, mostly as live cattle, although also in frozen and refrigerated forms. Due to seasonal variations in the domestic livestock supply, Peru's cattle and beef imports are highly variable.

In spite of the Cartagena Agreement, which calls on it to buy meat from Bolivia, Peru buys from other sources due mainly to hygienic factors. Nevertheless, it has been estimated that in the late 1960s about 15,000 head of cattle were smuggled annually into Peru from sources in the Bolivian Altiplano (Hunting and Vivado, 1973, p. 124). Since 1967, Colombia has replaced Argentina as the leading meat supplier of the Peruvian market. Explanations of this phenomenon lie in shrinking Argentinian exportable surpluses and aggressive export promotion of agricultural commodities by the Colombian government.

Peru's continued reliance upon meat imports throughout the 1980s cannot be doubted. Using two sets of parameters, JUNAC (1979, p. 52-8) has estimated Peruvian beef imports in 1990 to range from 53 to 124 thousand MT. Market prospects for Bolivian beef in Peru depend basically upon product quality. Hunting and Vivado (1973, p. 134) believe that access could be obtained if Bolivia could provide regular supplies of a clean product at competitive prices.

The Chilean market   Cattle production areas are located in the southern regions of Chile, while some fattening activities exist in the center. There has been little growth in the country's cattle population in the last 50 years, yet the human population has more than doubled.

In spite of several programs directed to benefit the livestock industry, the country is found to be increasingly dependent upon meat imports. Meat imports are channeled through ACE (Agricultural Commerce Enterprise) following guidelines established by the agricultural planning division. There are no taxes nor tariffs for imports of cattle or carcasses. In the years since the Pinochet government took office, price controls have been restricted to a limited range of products. Volumes and prices of meat and cattle imports were left free to accommodate to market conditions.

The main suppliers of the Chilean beef market are Argentina, Brazil, Uruguay, and New Zealand. Live cattle imports are mostly transported by ocean vessels, while chilled and frozen beef imports arrive by plane. As a matter of fact, beef air-transported from sources in Argentina to Chile represents one of the principal components of South American air traffic.

In the early 1970s, Bolivian beef exporters obtained a contract to deliver 400 MT per month to consumers in northern Chile. These exports confronted several problems, such as the inability of FEGABENI to regulate supplies from its members, the absence of a central cold storage facility, and the scarcity of raw material. Bolivian beef usually obtained the lowest prices due to its low quality and poor presentation.

Bolivian beef is allowed to enter only into the northern part of Chile, where sanitary regulations are lower, and cannot enter into other regions unless it originates in well controlled disease-free zones, is processed in approved slaughterhouses, and deboned. Hunting and Vivado (1973, p. 146) expected in the early 1970s that eventually sanitary norms would have national application and would be similar to those prevailing in the United Kingdom.

Exports of live cattle from Bolivia to Chile are relatively limited, having totalled around 1,500 head in 1972. These animals are shipped from sources in Beni to the city of Cochabamba, and from this point are transported by rail to Antofagasta, Chile (Hunting and Vivado, 1973, p. 133). According to these same authors, there is also an undetermined number of cattle smuggled from Bolivia into Chile, which may have amounted to about 5,000 head in 1972.

In the early 1970s, average meat consumption per capita in Chile was 33.3 Kgs. per year, higher than in Brazil, Bolivia and Peru (Kurian, 1979, p. 259). According to Brown, Chilean meat consumers prefer freshly killed beef to frozen or chilled forms (1966, p. 67).

The country's beef demand was expected to increase between 3.4 to 5 percent annually, considering that population increases at a rate of 2.2 percent per year and per capita demand for beef increases at a rate ranging from 1.2 to 2.8 percent per year (Hunting and Vivado, 1973, p. 133). The Hunting and Vivado consultants (1973, p. 133) considered it possible that Chile could be importing some 82,000 MT of beef by 1980. Considering the Chilean provinces of Tarapaca, Antofagasta, Atacama and Coquimbo, Hunting and Vivado (1973, p. 147) estimated the potential market for Bolivian beef to be around 3,500 MT in the early 1970s.

The Brazilian market   The Brazilian meat industry is linked to the pasture lands of Minas Gerais, San Paulo, the central west, and the south of the country. Almost one-half of the cattle is located and about two-thirds of the beef output originate in the San Paulo, Rio Grande do Sul, and Minas Gerais areas. The magnitudes of the Brazilian cattle herd and annual beef output are impressive, and in 1978, amounted to 90 million head and 2,250,000 MT, respectively, (United Nations, 1979, p. 117-232). Brazilian live cattle and beef imports were well over half a million head in 1978.

In the 1960s, Brazilian cattle were imported into Bolivia to be slaughtered in the cities of Cochabamba and Santa Cruz. However, as beef consumption increased in the cities of San Paulo, Manaus, Porto Velho and Rio Branco and the completion of BR-364 (Porto Velho-Brazilia highway) and BR-319 (Porto Velho-Manaus highway) which linked the Rondonia region with other parts of the country, exports of live cattle to Brazil from Beni and Santa Cruz sources began to take place. A large share of these Bolivian exports were traded without official permits. One source estimates that in 1976 alone, 69,000 head of cattle were illegally exported to Brazil (JUNAC, 1979, p. 14). Consequently, it can be inferred that the entire Beni cattle production surplus, which cannot be sold in Bolivia, is channeled to Brazilian markets, due to the absence or inadequacy of transport linkages to other markets. The main export outlet of Beni cattle bound to Brazilian markets is the border town of Guayaramerin in Vaca Diez province. The point of entry into Brazil is the locality of Guajara-Merim on the shore of the Itenez river, across from Guayaramerin.

Export volumes

We can assume that price and quality differentials notwithstanding, given the gigantic size of the Brazilian market, Beni cattle producers can sell their entire surplus output in this country. Moreover, once a reliable system of hygiene, veterinary inspection and health control is implemented, both Peru and Chile can be expected to buy Bolivian beef (Hunting and Vivado, 1973, p. 24).

Consequently, it can be postulated that any one of these markets could absorb the entire Bolivian beef surplus, namely 114,623 head (19,485,880 Kgs.) in 1980 and 195,770 head (39,154,000 Kgs. of high quality product) in 1990, as table 16 indicates.

Table 16. Bolivian cattle-beef exportable surpluses (1980 and 1990)[a]

	1980		1990	
	No. of head	Kilograms	No. of head	Kilograms
Output	466,491	79,303,470	658,685	131,737,000
Consumption	351,868	59,817,590	462,915	92,583,000
Surplus	114,623	19,485,880	195,770	39,154,000

[a]Source: Tables 12 and 14.

Type "L" plants - processing costs, capacities and locations

Slaughter costs in type L plants are low-nonstandardized inasmuch as they include different types of services. In Table 17 are shown the characteristics of slaughter costs in some key locations.

Table 17. Type "L" plants - slaughter costs[a]

City	Cost ($b/head)	Slaughter costs
La Paz	5	Slaughter plus butcher's own labor
Cochabamba	5	Idem
Oruro	140	Slaughter plus transport to market, not including washing offals and loading out, plus butcher's own labor
Santa Cruz	105	Slaughter plus transport to market, washing offals, and loading out plus butcher's own labor
Trinidad	80	Slaughter only

[a]Sources: JUNAC, 1978, p. 81; FAO/World Bank, 1978, p. 9.

In addition to the charges previously indicated, municipalities retain the animal hides as a tax for slaughter services. While most municipalities take the hides, some accept their cash equivalent. All Beni cattle must pay the municipal tax which ranges between $b 100 - 120, which is the cash equivalent of the hide. Beni cattle must also pay a slaughter tax of $b .20 per Kg. ($b .50 per Kg. when sold to COMIBOL) to repay BECASA's debt; \$b .20 per Kg. for FEGABENI; and \$b .40 per head, also to repay BECASA's debt (FAO/WB, 1978, p. 5).

In table 18 are shown the numbers of slaughterhouses in Beni, with and without cold stores, as well as the total beef output for each province, and the estimated annual processing capacity in 1978. There was no difficulty in determining the relevant data for regions 1-5. However, for regions 6-12, it was not possible to pinpoint the exact location of various slaughterhouses within a given province. Only the following plants were found to be located within a specific region: "Corfomento" in region 6; "Santa Rosa", "La Asunta", "El Retiro", "Palmira", and "La India" in region 7; "Venecia", "Angora", "La Paz", "Maniqui", "Suarez", "Maniqui Ltda", and "San Borja" in region 8; "Nieves", "San Francisco", "Santa Rita", "Paraiso", "El Rosario", "Bella Union", "Inglaterra", "Santa Ana", "El Peru", and "La Paz" in region 9; "La Esperanza" in region 10; "Miraflores", and "San Ignacio" in region 11; and "San Lorenzo" and "Moxos" in region 12. Those plants whose locations within a province could not be found, were evenly allocated among the relevant regions.

The slaughterhouses located at El Desengano ("Frigorifico Procar Limitada"), Trinidad ("Reyes") and San Juan ("San Juan"), the former in Moxos province and the latter two in Cercado province, have processing capacities of 90, 150, and 60 head per day, respectively. All other plants have been assumed to have a daily processing capacity of 30 head of cattle. All type "L" slaughterhouses in Beni are assumed to operate

Table 18. Beni: Type "L" slaughterhouses - location, processing capacity, and outputs (1978)[a]

Province	Region	Number of slaughterhouses: w/o cold store	Number of slaughterhouses: with cold store	Beef output (Kgs.)	Existing capacity (Kgs./year)	Existing capacity (no. of head/year
Marban	1	1	-	-	1,326,000	7,800
Cercado	2	3	1	1,900,000	10,608,000	62,400
Itenez	3	5	1	780,000	7,956,000	46,800
Mamore	4	3	2	700,000	6,630,000	39,000
Vaca Diez	5	0	0	0	0	0
Ballivian		11	8	4,220,000	25,194,000	148,200
	6	1	2	-	3,978,000	23,400
	7	5	2	-	9,282,000	54,600
Yacuma		8	3	3,200,000	14,586,000	85,800
	9	5	3	-	10,608,000	62,400
	10	3	0	-	3,978,000	23,400
Moxos		13	1	2,700,000	21,216,000	124,800
	11	5	1	-	10,608,000	62,400
	12	8	0	-	10,608,000	62,400
Total		44	16	13,500,000	87,516,000	514,800

[a]Source: Based on statistics obtained from Comite Nacional de Carnes, MICT, La Paz-Bolivia, 1979.

260 days per year, eight hours per day.

It is assumed that each region has only one plant with a processing capacity equal to the aggregated processing capacity of all plants in the region. Such unique plants are assumed to be located at the "central point" of each region.

Table 19 shows the number of slaughterhouses, beef outputs, and installed processing capacities in regions other than Beni in the year 1976. For regions 13, 14 and 15, information was obtained from the 1978 FAO/World Bank mission report. Existing plant capacities were estimated by multiplying the number of days worked per year by maximum daily kills. Daily kill capacities in the Achachicala, Oruro, Cochabamba and Santa Cruz slaughterhouses were 120, 30, 100 and 200 head, respectively. The plants in Achachicala and Santa Cruz operated 324 days per year, while the plants in Oruro and Cochabamba operate 365 and 329 days per year, respectively. Existing slaughter capacity serving the COMIBOL minefields was estimated knowing that these consumers received about 13,000 head of cattle on foot from non-Beni sources in 1976 (JUNAC, 1978, p. 5).

It is assumed that Bolivia is not interested in exporting low quality beef, which commands lower prices and presents health hazards. With the exception of the market in northern Chile, there has not been interest in low quality Bolivian beef, and it can be expected that by 1990 hygienic and health standards in Chile will have nationwide application and the low quality product from Bolivia will not be accepted. To reflect the fact that regions 16, 17 and 18 will

Table 19. Non-Beni regions: type "L" slaughterhouses - location, processing capacity and outputs (1976)[a]

Region	Locality	Number of slaughter-houses	Beef Output (Kg.)	Existing capacity (Kgs./year)	Existing capacity (no. of head per year)
13	City of La Paz	1	9,163,000	11,531,100	67,830
	Achachicala	1	5,594,530	6,609,600	38,880
	City of Oruro	1	1,358,470	1,861,500	10,950
	COMIBOL minefields	-	2,210,000	3,060,000	18,000
14	City of Cochabamba	1	5,585,010	5,593,000	32,900
15	5 Km. from City of Santa Cruz	1	10,218,020	11,016,000	64,800
16	Arica	-	-	0	0
17	Lima	-	-	0	0
18	Guayara-Merim	-	-	0	0
Total		4	24,966,030	28,140,100	165,530

[a]Sources: FAO/World Bank, 1978, p. 1-10.

not consume low quality beef from Bolivian sources, type L beef demands and slaughter capacities in these regions have been set equal to zero.

As can be observed in Table 19, slaughter plants in regions 13, 14 and 15 were already operating close to their maximum capacities in 1976. No new type "L" processing capacity has been built in any one of these regions since that year, and none is expected in the future. With the exception of resources channeled to the maintenance of existing buildings and equipment, it is assumed that all new investments into slaughterhouse development will be directed to the construction and equipment of type "H" facilities. Consequently, the processing capacities are to be considered unchanged in 1980 and 1990.

Table 20 summarizes the processing capacities of all type "L" slaughterhouses, and presents estimated processing costs per head and per kilogram of beef.

Type "H" plants - processing costs, capacities and location

To analyze slaughterhouse location patterns in the present dissertation, four sizes of type H slaughterhouses have been conceived, that is plants with a daily slaughter capacity of 30, 60, 100, and 200 cattle per day. Tables 21, 22, 23, and 24 show the capital costs, manpower requirements and labor costs, annual operating costs and total average processing costs for each one of these plants.

Table 20. Type "L" plants - processing capacities and costs[a]

Region no.	Processing capacities: No. head /year	Processing capacities: Kgs. /year	Processing costs[b]: $b/head	Processing costs[b]: $b/Kg.[c]
1	7,800	1,326,000	50	.25
2	62,400	10,608,000	80[d]	.40
3	46,800	7,956,000	50	.25
4	39,000	6,630,000	50	.25
5	0	0	-	-
6	23,400	3,978,000	50	.25
7	54,600	9,282,000	50	.25
8	70,200	11,934,000	50	.25
9	62,400	10,608,000	50	.25
10	23,400	3,978,000	50	.25
11	62,400	10,608,000	50	.25
12	62,400	10,608,000	50	.25
13	67,830	11,531,100	30[e]	.15
14	32,900	5,593,000	50[f]	.25
15	64,800	11,016,000	80[f]	.40
16	0	0	-	-
17	0	0	-	-
18	0	0	-	-

[a]Sources: JUNAC, April 1978, p. 67,
FAO/World Bank, 1978, p. 16,
JUNAC, 1978, p. 65-6.

[b]With the exception of regions 2, 13, 14, and 15, all others have been arbitrarily attached a processing cost per head of $b 50.

[c]Assuming a carcass weight of 200 Kgs.

[d]This cost corresponds to the Oruro plant. (JUNAC, 1978)

[e]FAO/World Bank, 1978, p. 16.

[f]JUNAC, 1978, p. 65-6.

Table 21A. Type "H" slaughterhouses - capital costs, civil works and buildings ($b 000)[a]

Concept	Daily processing capacity (no. of head) 30	60	100	200
Site preparation	192	384	400	400
Roads, paving	540	540	540	540
Security fence	400	400	400	400
Stockyards and office	1,680	1,680	1,680	1,680
Slaughterboard and offals bldg.	1,770	3,500	3,500	3,500
Chiller building	2,520	5,040	6,902	8,120
Hide house	360	720	841	990
Blood, coagulation and incineration	2,592	518	550	648
Gate house	60	60	60	60
Amenities and administration	576	1,152	1,360	1,600
Sewer, stormwater and reticulation	120	220	240	240
Water mains (underground)	36	72	85	100
Subtotal	8,513	14,286	16,558	18,278

[a] Source: Adapted from FAO/World Bank, 1978, Vol. II, Annex 5, Attachment 2, Table 1.

Table 21B. Type "H" slaughterhouses - capital costs, utilities ($b 000)[a]

Concept	Daily processing capacity (no. of head) 30	60	100	200
Hot water boiler (including fuel and stack)	240	480	-	-
Steam boiler (including fuel and stack)	-	-	900	1,200
Steam mains	-	-	240	320
Hot water piping, pumps, mixers, tanks	216	432	-	-
Heat exchanger and hot water pumps	-	-	300	400
Cold water pumps	144	288	60	80
Oil fuel tank	36	72	85	100
Chiller evaporators (installation)	480	960	1,700	2,000
Refrigeration engine room equipment	480	960	1,300	2,000
Electrical reticulation and controls	480	960	1,200	1,600
Waste water treatment	400	400	400	400
Water reticulation inside buildings	-	-	320	320
Subtotal	2,476	4,552	6,505	8,420

[a]Source: Adapted from FAO/World Bank, 1978, Vol. II, Annex 5, Attachment 2, Table 1.

Table 21C. Type "H" slaughterhouses - capital costs, machinery and equipment ($b 000)[a]

Concept	Daily processing capacity (no. of head) 30	60	100	200
Cattle dressing equipment	540	1,080	3,262	4,660
Miscellaneous slaughter equipment	216	432	720	-
Offal room	96	192	406	580
Chiller, rails and tree	360	720	574	820
Office and amenities	96	192	220	240
Laundry	48	96	100	100
Blood coagulation	36	72	602	860
Incinerator	36	72	85	100
Hide house	72	144	160	160
Workshop	36	72	84	120
Subtotal	1,536	3,072	6,213	7,640

[a]Source: Adapted from FAO/World Bank, 1978, Vol. II, Annex 5, Attachment 2, Table 1.

Table 21D. Type "H" slaughterhouses - capital costs, engineering, overhead, spares ($b 000)[a]

Concept	Daily processing capacity (no. of head) 30	60	100	200
Design and engineering (8%)	1,002	1,753	2,342	2,747
Organization and start up equipment (2%)	250	438	585	687
Initial stock spare parts (5% of table 21B and 21C)	200	381	636	803
Subtotal	1,452	2,572	3,563	4,237
TOTAL	13,977	24,482	32,839	38,575

[a]Source: Adapted from FAO/World Bank, 1978, Vol. II, Annex 5, Attachment 2, Table 1.

Table 22. Type "H" slaughterhouses - manpower requirements and labor costs ($b)[a]

	Plant daily processing capacity (no. of heads)							
	30		60		100		200	
Position	No.	Mo. salary	No.	Mo. salary	No.	Mo. salary	No.	Mo. salary
Manager	1	8,000	1	8,500	1	9,500	1	11,000
Foreman	1	4,000	1	4,000	1	4,200	1	4,500
Clerks	1	2,000	2	2,000	2	2,000	3	2,000
Gateguards	1	2,000	1	2,000	1	2,300	2	2,800
Workers	13	2,500	18	2,500	23	2,500	34	2,500
Chill room	2	3,000	2	3,000	2	3,000	2	3,000
Operation & maintenance	2	3,500	3	3,500	3	3,500	4	3,800
Total required manpower	21		28		33		47	
Monthly wage bill		61,500		80,000		94,000		133,300
Yearly wage bill		1,033,200		1,344,000		1,579,200		2,239,440

[a]Sources: FAO/WB, 1978; Eriksen, P. J., 1978, p. 27.

Table 23. Type "H" slaughterhouses - annual operating costs ($b 000)[a]

Concept	Unit of measurement	Unit cost ($b)	Daily processing capacity (no. of heads) 30	60	100	200
Labor			1,033	1,344	1,579	2,339
Oil Fuel	litre	1	72	144	252	360
Electricity	kwh	0.6	36	72	168	240
Water[b]	M^3	1	16	32	52	104
Consumables			120	240	329	470
Repairs & maintenance			240	480	980	1,400
Salt and others[c]			156	312	520	1,040
Office supplies			24	48	84	120
Insurance (3% of capital costs)			375	657	878	1,030
General expenses			29	59	112	160
Total			2,101	3,388	4,954	7,163

[a]Sources: FAO/WB, 1978; Eriksen, P. J., 1978, p. 27.

[b]Assuming a water requirement of 2,000 litres per head.

[c]Assuming $b 20 per head.

Table 24. Type "H" slaughterhouses - total average processing costs ($b)[a]

Concept	Daily processing capacity (no. of head)			
	30	60	100	200
Capital costs (000)	2,275	3,984	5,345	6,278
Operating costs (000)	2,101	3,388	4,954	7,163
Total annual costs (000)	4,376	7,372	10,299	13,441
Annual throughput (no. of head)	7,800	15,600	26,000	52,000
Annual throughput (Kgs. of beef)	1,560,000	3,120,000	5,200,000	10,400,000
Processing costs per head	561	472	396	258
Processing costs per Kg.	2.80	2.36	1.98	1.29

[a]Note: Plants are assumed to operate at full capacity. Carcass weights are estimated to average 200 Kgs.

The FAO/World Bank mission report of 1978 considered the construction, rehabilitation or equipment of two types of plants, with differing processing capacities, for 50 head of cattle (type A) and for 200 head (type B). General features of the smaller plants are as follows: a minimally mechanized dressing system, in which all transfers of carcasses are done by manual pushing; the holding pens have a capacity equivalent to one day's kill; and an oil fired hot water boiler provides water to the processing operations. The larger plants (type B) have the following features: a minimally mechanized "on-the-rail" system having a sloping gravity rail with mechanical stops at work stations; built adjacent to airports; have enough yard space for a little over one day's supply (250 head); and have a steam boiler for heating hot water, cooking the hooves, coagulating and drying the blood and providing hot water. Common features of the two types of plants include chilling facilities for one day's slaughter. Both types of plants are in charge of delivering meat to local retail outlets, water supplies are obtained from the town pipes and plants operate 8-hours a day, six days a week. Both plants have facilities for salting of hides and skins, a small laboratory, offal handling rooms and equipment, and other primary treatment of effluent.

Capital costs for plants with daily processing capacities of 30 and 60 head were adopted proportionally from capital cost data of FAO/World Bank's type A plants, while capital costs for plants with daily slaughter capacity of 100 cattle were adapted proportionally from cost figures of FAO/World Bank's type B plants. In general, it has been assumed that plants with daily processing capacities of 30 and 60 head account for 60 and 120 percent, respectively, of the capital costs corresponding to a type A plant. On the other hand, costs for those plants with daily processing capacities of 100 head have been assumed to equal 85 percent of the civil and building works and utility costs (Table 21A and Table 21B) and 70 percent of the machinery and equipment costs (Table 21C) corresponding to a type B plant.

Costs for local delivery of meat, which the FAO/World Bank plants include, have been eliminated. Likewise, all costs related to the processing of animals other than cattle have not been considered. Costs related to chiller buildings, and installation of chiller evaporators have been doubled, recognizing that chilling capacity for one day's slaughter--adopted for the FAO/World Bank plants--is not sufficient.

To estimate manpower requirements, use was made of the study made by Eriksen in 1978, in which the manning of slaughterhouses with daily processing capacities of 30, 60 and 100 head was analyzed. In relation to the plants with daily processing capacities of 200 head, it was estimated that they need about 50 percent more staff than those plants with daily capacities of 100 head. Aggregated labor costs consider payment of 14 monthly salaries, in addition to a 20 percent allowance for payment of overtime, sick leave, holidays, etc.

Operating costs were obtained following an approach similar to the one employed to estimate capital costs. Using FAO/World Bank figures, it was assumed that operating costs of plants with processing capacities of 30 and 60 head per day are equivalent to 60 and 120 percent, respectively, of the corresponding costs of type A plants. Likewise, operating costs of plants processing 100 cattle per day are assumed to equal 70 percent of the corresponding costs in type B plants.

To estimate processing costs per head of cattle and per Kg. of beef, capital costs were converted to annuities, assuming a 10-year investment recovery period, and a 10 percent interest rate.

The average costs of processing shown in Table 24 correspond to the different sizes of slaughterhouses operating at full capacity. In table 25 are also included the costs of processing for situations in which these plants do not operate at full capacity. With the exception of the 30/head/day plant size, for which five operation levels are considered, average slaughter costs are estimated for four levels of operation (65, 80, 90, and 100 percent).

To determine processing costs for operation levels less than full capacity, capital costs are considered to be unchanged, and operating costs are reduced proportionately. Labor costs are lowered because of smaller numbers of workers. Other labor categories (i.e., manager, foreman, clerks, etc., shown in Table 22) are assumed to remain unchanged. Insurance costs, based upon capital costs are held constant for all throughput levels.

Table 25. Type H slaughterhouses - total average processing costs at various levels of operation ($b)

	30/head/day					60/head/day			
	Operation level (%)					Operation level (%)			
Concept	50	65	80	90	100	65	80	90	100
Capital costs (000)	2,275	2,275	2,275	2,275	2,275	3,984	3,984	3,984	3,984
Operating costs (000)	1,503	1,692	1,881	1,991	2,101	2,653	2,987	3,208	3,388
Total annual costs (000)	3,778	3,967	4,156	4,266	4,376	6,637	6,971	7,192	7,372
Annual through-put (no. of heads)	3,900	5,070	6,240	7,020	7,800	10,140	12,480	14,040	15,600
Annual through-put (MT of beef)	780	1,004	1,248	1,404	1,560	2,028	2,496	2,808	3,120
Processing costs per/hd.	968	782	666	607	561	654	558	512	472
Processing costs per/kg.	4.84	3.91	3.33	3.03	2.80	3.27	2.79	2.56	2.36

100/head/day				200/head/day			
Operation level (%)				Operation level (%)			
65	80	90	100	65	80	90	100
5,345	5,345	5,345	5,345	6,278	6,278	6,278	6,278
3,745	4,289	4,621	4,954	5,296	6,090	6,648	7,163
9,090	9,634	9,966	10,299	11,574	12,368	12,926	13,441
16,900	20,800	23,400	26,000	33,800	41,600	46,800	52,000
3,380	4,160	4,680	5,200	6,760	8,320	9,360	10,400
538	463	426	396	342	297	276	258
2.68	2.32	2.13	1.98	1.71	1.49	1.38	1.29

Transportation costs

It is a frustrating task to attempt to collect meaningful transportation data for cattle and beef in Bolivia. Available publications offer only fragmentary information. This situation is not entirely a fault of industry researchers, but also a reflection of the general lack of recording and data reporting services provided in the country, the diversity of pricing practices, and the absence of a well coordinated transport system.

Live cattle The transportation of live cattle and beef involves various costs in addition to out-of-pocket payments. Some of these costs are related to the loss of animals (due to death, disease, or theft), the loss of weight (shrinkage), and the loss of time. The measurement of these costs is especially important when comparisons of different transportation modes are being made.

Shrinkage is defined as the loss in weight occurring between feedlot (ranch) and market scales. It is usually related to the size of the cattle, and varies according to the length of the journey, the condition of the animal at loading time, the degree of comfort en route, the kinds of feeds used, the degree of finish of the cattle, and the kill at the market. Larger shrinkage percentages are associated with longer journeys, although the greatest losses take place in the first miles travelled. As far as possible, cattle being loaded should be in normal condition, that is, adequately fed, watered and rested. Newmann (1977, p. 785) notes that during extremes of hot or cold weather, and when animals are transported in crowded and slow trucks, with rough runs and frequent stops, shrinkage is unusually high.

For the Andean subregion, weight losses resulting from deficient transportation of cattle have been estimated to be 12 percent, one-half of which are carcass loss (JUNAC, 1979, p. 19). According to one study undertaken in Bolivia, in which one group of Beni carcasses were flown directly to Oruro, and another group flown to La Paz and then trucked to Oruro, it was found that shrinkage percentages were different, being .52 percent for the first group and 3.44 percent for the second (Hunting and Vivado, 1973, p. 113). Unfortunately, the type of plane, journey time, time lost in loading and unloading operations corresponding to such study are not indicated. Hunting and Vivado (1973, p. 311) estimated that the loss of live animal weight occurring during cattle transportation, in railroad and truck exceeds 4 percent, and on foot can represent up to 10 percent of the herd. Losses in transit in relation to journey length, season, route, etc., are not known.

JUNAC employed weight loss figures to recommend transport alternatives for Beni cattle and beef. Three different alternatives were considered: (a) cattle bound for La Paz are slaughtered in Beni and flown to market, while cattle bound for Cochabamba and Santa Cruz are transported live to their destinations; (b) live cattle are trucked from Beni to these three markets; (c) and cattle are slaughtered in Beni and transported to their markets in refrigerated trucks. Their data indicated that during transportation live cattle suffer a weight loss equivalent to 10 Kgs. per day; one carcass, without refrigeration, loses by dehydration 10 percent of its weight in 24 hours; and one carcass, properly refrigerated, loses about 2 percent of its weight in the first 4 hours and 1 percent per day afterwards. JUNAC recommended the third alternative (April 1979, p. 4).

In order to estimate weight and animal losses of cattle and beef in transit, the following factor and product prices have been used: $b 13.50 per Kg. of live cattle, and $b 32 per Kg. of beef. These prices were recently registered in the city of Trinidad (Manuel Vivado P., P. O. Box 3534, La Paz-Bolivia, personal correspondence, 1980). Live cattle being transported by rail or truck are assumed to lose 10 Kgs. of weight per day in transit. This weight loss is assumed to occur in the following manner: 3 Kgs. during the first hour in transit and one Kg. during each additional hour, up to a maximum loss of 10 Kgs. per head. Live cattle being transported by river barge are assumed to experience no weight losses because of the existence of adequate feeding and watering facilities along the way. Live cattle being trailed are assumed to lose 1.34 Kgs. per day of journey. This live weight loss in transit was obtained by taking the 10 percent loss indicated by Hunting and Vivado (1973, p. 311) and relating it to an average 30 day, 502 Km. trail. Live cattle are assumed to weigh 400 Kgs. at the time of departure.

Nonrefrigerated beef carcasses are assumed to shrink .67 percent per hour, during the first 6 hours after slaughter (Dennis G. Olson, Dept. of An. Sci., ISU, personal interview, 1981).

Refrigerated carcasses are assumed to lose 2 percent of their weight in the first 4 hours of travel and 1 percent per day afterwards (JUNAC, 1979, p. 4).

To attach a cost to time losses in transit, an average price of live cattle equal to $b 5,400 (400 Kgs. x $b 13.50) has been employed. Every day lost in transit, the cattle grower or merchant loses the interest that the cash equivalent of each animal would have earned if deposited in a bank. We use a 10 percent nominal annual rate of interest, which is commonly earned by savings accounts in the Bolivian banking system (Ladman, et al. 1977, p. 48). Assuming daily compounding, the monetary loss per head for cattle in transit is roughly equal to $b 1.5 per day.

To estimate times in transit of live cattle, the following speeds have been used: on foot, 20 Km./day; truck, 40 Km./hour; rail, 25 Km./hour; barge, 90 Km./day upstream and 180 Km./day downstream.

Railroad Hunting and Vivado provide information concerning the movement by rail of a 25 head lot of cattle from Robore to the city of Santa Cruz. The costs of shipping this lot totalled $b 2,000, which included $b 100 for driving the cattle and loading at the origin; $b 1,750 for rail transportation; $b 50 for unloading at destination; $b 50 for driving the cattle to the slaughterhouse; and $b 50 for use of corrals before slaughter (1973, p. 118). This indicates a cost per head of $b 70 for the 413 Km. journey, or $b .17 per head per Km.

River barge Data concerning river transportation costs are extremely limited. What little is available presents an incomplete picture of prevailing conditions, inasmuch as no distinctions are made with respect to season, direction, commodity, size of cargo, and length of journey. Barge transport costs have been estimated to be about one-third of road transport costs (FAO/ World Bank, 1978, p. 16). According to this same source, because during river transportation animals are watered and fed, there is little loss of condition in transit. In Table 26 are presented some features of the principal river routes for cattle movements in Beni. Notice the long distances between ports, which are a result of the meandering nature of rivers in Beni. As one source indicates, barge movement in these watercourses requires two miles of travel for every mile gained in the desired direction of travel (Daniel, Mann, et al. 1968, p. 256). Not considering on foot transportation of cattle, river barges are the slowest transportation mode, and especially so when moving upstream.

Truck In Table 27, are shown the most important road connections, of relevance to the cattle-beef industry, that now exist or are planned to be in operation by 1990. Note the low speeds at which vehicles travel along these routes, which average 40 Km. per hour. Traveling speeds are so low because of the hilly terrain, numerous curves, and narrowness that characterize most roads in Bolivia.

Table 26. Barge transportation costs for live cattle ($b/head)[a]

Route	Distance (Km.)	Days of travel[b] Upstream	Days of travel[b] Downstream	Cost per head ($b) Upstream	Cost per head ($b) Downstream
Puerto Salinas-Riberalta	728	8	4	291[c]	189[d]
Guayaramerin-Puerto Villaroel	1,317	15	8	527[c]	342[d]
Guayaramerin-Puerto Grether	1,460	17	9	584[c]	380[d]
Guayaramerin-Puerto Almacen[e]	903	11	5	361[c]	235[d]
Puerto Almacen-Puerto Villaroel	518	6[f]	3	200[b]	135[d]
Santa Ana-Puerto Villaroel	690	7	4	300[b]	179[d]
Santa Ana-Guayaramerin	651	7	4	260[c]	175[b]

[a]Sources and notes:

[b]Justiniano, Alf. E., Fuerza Naval Boliviana, La Paz-Bolivia, personal correspondence, 1980.

[c]FAO/World Bank, 1978.

[d]Assuming a tariff of $b .40/head/Km.

[e]Assuming a tariff of $b .26/head/Km.

[f]Puerto Almacen is the post serving the city of Trinidad.

Table 27. Truck transportation costs for live cattle ($b/head)[a]

Route	Distance (Km.)	Length of journey (hrs.)	Speed (Km./hrs.)	Tariff ($b/head)	Tariff[b] ($b/head/Km.)
Existing connections					
Puerto Villaroel-Cochabamba[c]	225	8	28.1	160	.71
Cochabamba-Oruro[c]	228	9	25.3	200	.88
Cochabamba-Santa Cruz	458	10[d]	38.1	230[e]	.50
Cochabamba-La Paz	498	12[d]	41.5	300[f]	.60
La Paz-Oruro	225	4.5	50	112[g]	.50
La Paz-Santa Cruz	903	21	45.5	530[h]	.59
Monteagudo-Sucre[c]	323	12	27	300	.93
Monteagudo-La Paz[c]	1,063	24	44	800	.75
Future connections[i] (1990)					
La Paz-Trinidad	580	12[j]	48.3	394	.68
Cochabamba-Trinidad	540	11[k]	51	367	.68
Santa Cruz-Trinidad	512	8[j]	64	348	.68
Cochabamba-Santa Cruz	424	5[l]	85	288	.68
La Paz-Riberalta	935	23	40	636	.68
San Ramon-Trinidad	367	6[m]	64	250	.68
Pt. Villaroel-Sta. Cruz	304	3.5[n]	85	207	.68

[a] Sources and notes:
[b] Tariffs per head per Km. assumed to equal the average of the existing connections.
[c] FAO/World Bank, 1978, p. 15.
[d] JUNAC, 1979, p. 21.
[e] Caceres, et al. 1974, p. 49.
[f] Estimated to be slightly less than from Cochabamba to Oruro and from Oruro to La Paz.
[g] Assuming a tariff of .50/head/Km.
[h] Through the city of Cochabamba.
[i] Distances obtained from SNC, 1979.
[j] JUNAC, 1979, p. 22.
[k] Assuming an ave. speed of 51 Km./hr.
[l] FAO/World Bank, 1978, p. 13.
[m] Assuming an ave. speed of 64 Km./hr.
[n] Assuming an ave. speed of 85 Km./hr.

<u>On foot</u> Table 28 shows the principal cattle trails in the Bolivian lowlands, and the approximated distances and transport costs.

The Hunting and Vivado (1973, p. 116) consultants have presented an illustration of on foot transportation of cattle from Concepcion to the Okinawa colony in Santa Cruz. Twenty-five animals were trailed during four days, and the following costs were indicated: driving ($b 30/head); use of corrals along the way ($b 4/head); crossing of the Grande river ($b 4/head); and payment of toll (guia de transporte) upon arrival to Okinawa ($b 10/head).

On foot transportation of cattle usually requires smaller out-of-pocket costs but causes greater weight, animal, and time losses than other modes. The lack of adequate feeding and watering facilities along cattle trails in Beni during the dry season--when they are passable--increases the shrinkage of cattle being trailed. Because of low average speeds, which average 20 Km/day, time losses in transit and those due to death, straying, theft, and disease are increased.

It is not an easy undertaking to find information concerning weight and animal loss percentages occurring during cattle trailing in Bolivia. These losses are likely to vary according to route, season, size of herd, and expertise of the drivers. Availability of water and feed, length, type of terrain, and temperature are some of the principal route factors affecting cattle shrinkage.

Transport costs for live cattle have been estimated for 1980

Table 28. Cattle trails in the lowlands[a]

Route	Days of travel	Approx. distance (Km)[b]	Cost[c] ($b/head) 1965	Cost[d] ($b/head) 1978	Cost ($b/head/Km) 1978
San Matias-Trinidad	40	787	120	450	.57
San Matias-Santa Cruz	30	585	80-120	375	.64
Corumba-Trinidad	60	900	120	450	.50
San Luis Caceres-Sta. Cruz	30	700	80	300	.43
San Luis Caceres-San Tavier	30	540	80	300	.55
Corumba-Santa Cruz	60	650	100	375	.58
San Matias-San Ignacio	30	750	85	319	.43
Santa Cruz-Trinidad	30-40	386	85-100	337	.89
Trinidad-Santa Cruz	30-40	386	50-70	225	.58
San Javier-Trinidad	30	315	70	192	.61
San Javier-Santa Cruz	7	195	30	112	.57
Concepcion-Santa Cruz	9	225	40	150[e]	.67
San Ignacio-Santa Cruz	14	466	60	225	.48
San Borja-S. Ana de Huachi	4-6	150			
Averages	30	502			.58

[a]Sources and notes:

[b]Distances have been calculated from Instituto Geografico Militar, 1980, p. 66.

[c]Manuel Vivado P., 1966, p. 48.

[d]Cost estimated assuming an increase of 275 percent from 1965.

[e]JUNAC, 1978, p. 66.

and 1990. These costs have been obtained using the figures shown in Table 29.

Table 30 presents the minimum transport costs of live cattle for the years 1980 and 1990. Those for 1990 have been estimated taking account of all the new transport linkages likely to be completed during the 1980s. In all cases, barge transportation of cattle is the least expensive. For short distances, less than 50 Km., on foot transportation is cheaper than truck. For distances less than 40 Km., on foot transportation is also cheaper than rail. For longer journeys, on foot transportation is heavily penalized by live weight losses and becomes the least convenient transport mode, as is shown in Table 31.

Beef Considering the 1980 transportation infrastructure, type "L" beef can be transported solely by airplane. In 1990, beef could be transported by refrigerated airplanes, trucks and railroad wagons.

Type "L" beef Air transportation costs for beef vary in relation to various factors, such as the type of route (meteorological and topographical conditions, distance, etc.), frequency of service, loading and unloading conditions, cargo characteristics, type of plane, etc. In Table 32 are shown recent air transport cost figures for nonrefrigerated, low quality beef. Note that the cost of transportation per kilo of beef varies significantly depending on the availability of Beni bound cargo, as well as on the type of plane. The lowest tariffs per unit of weight correspond to the larger planes,

Table 29. Live cattle transport costs[a]

Concept	On foot	Truck	Rail	Barge[b]	
				Upstream	Downstream
Out-of-pocket costs	$b .58/h/Km[c]	$b .68/h/Km[d]	$b .34/h/Km[e]	$b .40/h/Km	$b .26/h/Km
Time costs in transit			$b 1.5/head/day[f]		
Shrinkage	$b 18/h/day[g]	$b 135/h/trip[h]	$b 135/h/day[h]	--[i]	--[i]

[a]Sources and notes:

[b]Averages obtained from Table 26.

[c]Average obtained from Table 28.

[d]Average obtained from Table 27.

[e]Assumed to be one-half of truck out-of-pocket costs.

[f]Represents the interest lost that the cash equivalent of one head of cattle ($b 5,400) would have earned if deposited in a bank.

[g]Assuming a live weight loss of 1.34 Kgs. per day in transit and a live weight price of $b 13.5 per Kg.

[h]Assuming a loss of 3 Kgs. during the first hour of journey, and 1 Kg. during each additional hour, up to a maximum of 10 Kgs. per trip.

[i]Assuming that there exist adequate.

Table 30A. Live cattle transport costs ($b/kg) - 1980 transportation infrastructures

Year	Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1980	1		.45	2.32	2.33	1.50	2.80	2.82	2.01	.72	.64	1.00	1.99	3.76	2.13	2.64	5.25	8.83	1.50
1980	2	.45		1.87	1.70	1.21	1.99	2.46	1.51	.41	.32	.54	1.53	4.03	2.41	3.02	5.52	9.10	1.21
1980	3	2.32	1.87		.79	1.53	3.85	3.43	3.43	1.42	2.09	2.46	3.45	5.76	4.19	4.90	7.25	10.83	1.53
1980	4	2.33	1.70	.79		1.02	3.23	2.81	3.23	.90	1.57	1.93	2.92	5.24	3.66	4.74	6.73	10.31	1.02
1980	5	2.25	1.88	1.88	1.35		2.29	2.75	3.08	1.35	2.03	2.41	3.40	5.69	4.12	4.36	7.18	10.76	.05
1980	6	2.80	1.85	3.85	3.23	1.68		.46	.77	1.78	2.32	1.73	2.18	2.06	5.02	4.76	3.55	7.13	1.73
1980	7	2.82	2.46	3.43	2.81	1.98	.46		.62	1.11	2.30	1.64	2.04	2.53	3.93	4.18	4.02	7.60	1.98
1980	8	2.01	1.51	3.43	3.23	2.59	.77	.62		1.72	1.68	.94	1.42	2.86	3.93	4.55	4.35	7.93	2.59
1980	9	1.03	.62	1.26	.74	.87	1.72	1.11	1.72		.78	1.11	1.88	4.39	2.78	3.03	5.88	9.46	.87
1980	10	.64	.32	1.74	1.22	1.36	2.38	2.30	1.68	.55		.60	1.43	4.18	2.57	2.53	5.67	9.25	1.36
1980	11	.99	.54	2.10	1.56	1.70	1.73	1.69	.94	.87	.60		.99	4.57	2.96	2.91	6.06	9.64	1.70
1980	12	1.98	1.53	3.08	2.55	2.69	2.18	2.09	1.42	1.88	1.72	.99		5.53	3.95	3.90	7.02	10.60	2.69
1980	13	3.53	3.64	5.10	4.58	4.71	1.86	2.33	2.66	3.87	3.80	4.17	5.13		2.19	3.76	1.49	5.07	4.71
1980	14	1.90	2.01	3.51	2.97	3.10	5.23	3.40	3.53	2.26	2.17	2.56	3.55	2.19		2.24	3.68	7.26	3.10
1980	15	2.57	2.52	4.90	4.78	3.24	4.40	3.55	3.92	2.40	2.12	2.44	3.43	3.76	2.24		5.25	8.83	3.24
1980	16	5.02	5.13	6.59	6.07	5.20	3.35	3.82	4.15	5.36	5.29	5.66	6.62	1.48	3.68	5.25		4.43	5.20
1980	17	8.60	8.71	10.17	9.65	9.78	6.93	7.40	7.73	8.94	8.87	9.24	10.20	5.07	7.26	8.83	4.33		9.78
1980	18	2.25	1.88	1.86	1.35	.05	2.35	2.57	2.75	1.35	2.03	2.40	3.39	5.73	4.23	4.36	7.22	10.80	

Table 30B. Live cattle transport costs ($b/kg) - 1990 transportation infrastructures

Year	Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1990	1		.45	2.32	2.33	1.50	2.22	2.48	1.64	.72	.64	.79	1.53	2.84	2.13	2.17	4.34	7.91	1.50
1990	2	.45		1.87	1.70	1.21	1.99	2.27	1.31	.41	.32	.54	1.18	2.65	2.41	2.42	4.14	7.72	1.21
1990	3	2.32	1.87		.79	1.53	3.13	2.54	3.30	1.42	2.09	2.46	3.16	4.38	3.66	3.82	5.87	9.45	1.53
1990	4	2.33	1.70	.79		1.02	2.60	2.02	2.77	.91	1.57	1.93	2.63	4.21	3.66	3.98	5.70	9.28	1.02
1990	5	2.25	1.88	1.88	1.35		2.29	2.39	2.75	1.35	2.03	2.40	3.11	4.16	4.12	4.22	5.65	9.23	.05
1990	6	2.22	1.85	2.96	2.43	1.68		.46	.77	1.78	2.02	1.73	2.18	2.06	3.31	3.60	3.55	7.13	1.73
1990	7	2.48	2.27	2.37	1.85	1.98	.46		.62	.11	2.26	1.64	2.04	2.42	3.56	3.85	3.91	7.49	1.98
1990	8	1.64	1.31	2.94	2.40	2.59	.72	.62		1.72	1.25	.94	1.42	1.87	2.72	3.01	3.36	6.94	2.59
1990	9	1.03	.62	1.26	.74	.87	1.72	1.11	1.72		.78	1.09	1.79	3.57	2.78	2.89	5.06	8.64	.87
1990	10	.64	.32	1.71	1.22	1.36	2.02	2.26	1.25	.55		.51	1.19	2.62	2.49	1.73	4.11	7.69	1.36
1990	11	.79	.54	2.10	1.56	1.70	1.76	1.64	.94	.87	.51		.78	2.37	2.24	2.54	3.86	7.44	1.70
1990	12	1.53	1.18	2.80	2.26	2.40	2.18	2.04	1.42	1.59	1.19	.78		2.82	2.77	2.06	4.31	7.89	2.40
1990	13	2.84	2.65	4.38	4.21	4.16	1.86	2.33	1.87	3.57	2.62	2.37	2.82		2.19	3.64	1.49	5.07	4.16
1990	14	1.90	2.01	3.51	2.97	3.10	3.31	3.40	2.72	2.25	2.17	2.24	1.77	2.19		2.12	3.68	7.26	3.10
1990	15	1.84	2.42	3.17	3.98	3.10	3.60	3.55	3.01	2.26	1.98	2.44	2.06	3.64	2.12		5.13	8.71	3.10
1990	16	4.33	4.14	5.87	5.20	5.20	3.32	3.02	3.36	5.06	4.11	3.86	4.31	1.49	3.68	5.13		4.33	5.20
1990	17	7.91	7.72	9.45	9.28	9.23	6.93	7.40	6.94	8.64	7.59	7.44	7.89	5.07	7.26	8.71	4.33		9.28
1990	18	2.25	1.88	1.86	1.35	.05	2.34	2.57	2.75	1.35	2.03	2.40	3.39	4.15	4.23	4.22	5.64	9.22	

Table 31. Comparative transport costs of cattle ($b/head)

Km.	On foot	Truck	Rail	Barge Ups	Barge Downs
20	31.1	33.8	47.3	8.0	5.2
40	62.2	67.7	67.5	16.0	10.4
50	77.8	77.8	71.0	20.0	13.0
80	124.4	108.4	94.7	33.5	20.8
100	155.5	128.7	115.0	41.5	26.0
200	311.0	230.5	204.5	83.0	53.5
300	466.5	340.5	238.5	124.5	81.0
500	777.5	476.5	308.0	207.5	134.5
700	1,088.5	614.0	377.5	292.0	188.0
1,000	1,555.0	819.5	482.5	417.5	267.5
1,200	1,866.0	957.0	552.0	499.5	321.0

Table 32. Type "L" beef out-of-pocket air transport costs[a]

Route	Type of plane[b]	Cruising speed[c]	Cost per hr. of flight ($b)	Beni bound cargo (Kgs)	La Paz bound cargo (Kgs)	Total cargo (Kgs)	Tariff[d] ($b/Kg)	Tariff[e] ($b/Kg)	Tariff[d] ($b/Kg/Km)
La Paz-Trinidad-La Paz (828 Km.)	Convair 440	465 Km/hr	15,450	2,500	5,000	7,500	3.67	5.50	.0044
	DC-6	509 Km/hr	17,200	7,800	11,000	18,800	1.49	2.54	.0018
La Paz-Sta. Ana-La Paz (907 Km.)	Convair 440	465 Km/hr	15,450	2,500	5,000	7,500	4.01	6.02	.0044
La Paz-San Borja-La Paz (502 Km.)	Convair 440	465 Km/hr	15,450	2,700	4,500	7,200	2.31	3.70	.0046
La Paz-Reyes-La Paz (516 Km.)	C-46	301 Km/hr	7,000	3,200	5,500	8.700	1.37	2.18	.0026

[a]Sources: b - Information for the Convair 440 aircraft was provided by Mr. Manuel Vivado P., 1980, personal letter, while that for the DC-6 and C-46 aircraft was obtained from JUNAC, April 1978, p. 76; c - Green, William and Swanborough, Gordon, 1978; d - includes Beni bound and La Paz bound (beef) cargo; e - includes La Paz bound beef cargo.

which can transport larger payloads. For example, in the route La Paz-Trinidad-La Paz, costs per Kg. in the DC-6 aircraft are less than one-half of those in the Convair 440.

Table 33 shows type "L" beef transport costs for three types of planes. Note that because of its speed, no time losses occur with air transportation. Shrinkage losses are assumed to equal .67 percent of carcass weight per hour, during the first six hours after slaughter.

Table 33. Type "L" beef transport costs (1980 and 1990)

	Type of plane		
Concept	DC-6	C-46	Convair 440
Out-of-pocket costs ($b/Kg./Km)	.0018	.0026	.0044
Time loses	-	-	-
Shrinkage ($b/carcass/ hour)	$b 42.9	$b 42.9	$b 42.9

To estimate type "L" beef air transport costs, the figures for the C-46 aircraft were used. The tariffs for this type of aircraft were taken to be the most representative because of the 27 registered beef carriers in the country, 13 are C-46s, 5 are Convairs and only 3 are DC-6s (JUNAC, 1978, p. 75). Table 34 shows the straight line distances between the central points of each pair of regions, and

Table 34. Distances between central points (Km) and type "L" beef transport costs ($b/Kg)[a]

Region	Locality		Air transport costs ($b/Kg)						
			1	2	3	4	5	6	7
1	Loreto			.17	.78	.81	1.64	.99	.86
2	Trinidad		52		.56	.66	1.48	.88	.74
3	Magdalena		235	171		.25	1.00	1.23	1.05
4	San Joaquin		246	199	76		.87	1.06	.89
5	Guayaramerin		496	447	303	263		1.46	1.34
6	Reyes		298	266	372	321	442		.17
7	Sta. Rosa		261	224	319	268	405	53	
8	Sn. Borja		220	197	338	300	471	86	78
9	Sta. Ana		185	135	157	114	325	214	162
10	La Esperanza	Distance (Km)	65	22	207	202	443	244	202
11	Sn. Ignacio		103	79	252	234	458	196	160
12	Sn. Lorenzo		112	110	297	282	504	202	177
13	La Paz		385	414	561	529	690	258	286
14	Cochabamba		274	309	505	501	726	358	361
15	Santa Cruz		319	360	507	543	801	583	567
16	Arica		687	705	879	847	996	555	598
17	Lima		1,370	1,337	1,385	1,300	1,273	1,048	1,112
18	Guayara-Merim		496	447	303	263	3	445	406

[a]Source: Estimated from Instituto Geografico Militar, 1980, Mapa de la Republica de Bolivia, Carta Preliminar, 1974.

8	9	10	11	12	13	14	15	16	17	18
.73	.61	.21	.34	.37	1.27	.91	1.05	2.28	4.54	1.64
.65	.45	.07	.26	.36	1.37	1.02	1.19	2.34	4.43	1.48
1.12	.52	.68	.83	.98	1.86	1.67	1.68	2.91	4.59	1.00
1.00	.38	.67	.77	.93	1.75	1.66	1.80	2.81	4.31	.87
1.56	1.08	1.47	1.52	1.67	2.28	2.41	2.65	3.30	4.22	.10
.28	.71	.81	.65	.67	.85	1.18	1.93	1.84	3.47	1.47
.26	.46	.67	.53	.58	.95	1.19	1.88	1.98	3.68	1.34
	.62	.57	.40	.38	.76	.94	1.64	1.81	3.72	1.93
187		.41	.45	.60	1.37	1.34	1.67	2.43	4.07	1.07
174	123		.19	.30	1.22	.99	1.27	2.26	4.32	1.47
120	135	57		.16	1.04	.89	1.34	2.07	4.15	1.52
117	181	93	48		.92	.74	1.29	1.95	4.22	1.67
231	415	369	315	277		.77	1.80	1.05	3.93	2.30
283	405	300	270	223	234		1.05	1.50	4.70	2.41
496	504	384	405	391	544	318		2.49	5.32	2.66
547	733	681	625	588	318	454	753		3.30	3.31
1,123	1,230	1,305	1,252	1,273	1,186	1,420	1,605	995		4.23
472	325	444	460	505	694	727	802	999	1,276	

the air transport costs of low quality beef. It is assumed that the transport costs of type L beef are identical in either direction. An arbitrary cost of $b .10/Kg. has been entered to represent air or barge transportation, across the Itenez river, between the central points of regions 5 and 18.

Type "H" beef In 1990, high quality beef could be transported by refrigerated railroad wagons, airplanes, and trucks.

Railroad Table 35 shows carload rates for fresh and frozen meats. Maximum carload capacity is assumed to range from 30 to 40 tons of cargo. However, these tariffs are not very meaningful given that ENFE does not have refrigerated wagons (JUNAC, October 79, p. 23). Illustrating the fragmentary nature of published rates, ENFE does not quote less-than-carload rates, nor those corresponding to seasonal-directional-volumetric-distance variations. Unfortunately, information is not available concerning time losses before loading, in transit, and for outloading.

Airplane To estimate air transport costs of high quality beef, the costs of renovating current air carriers must be considered, so that these can provide hygienic and adequate refrigerated beef transport services. Hunting and Vivado (1973) estimated that the cost of improving a C-46 airplane to carry high quality beef was equal to $4,188. This amount included the provision of an auxiliary generator, air conditioning, insulation, aluminum floors, steel beams, installation and others. Table 36 presents updated C-46 aircract conversion costs. Assuming a three-year investment

Table 35. Carload railroad rates for fresh and frozen meats (1979)[a]

Origin	Destination	Distance (Km)	Rate ($b/MT)	$b/MT (Km)
Existing connections				
Cochabamba	La Paz	498	394.7	.79
Cochabamba	Oruro	262	243.4	.92
Cochabamba	Potosi	702	542.6	.77
Cochabamba	Uyuni	554	435.0	.78
La Paz	Charana	271	250.1	.92
La Paz	Ollague	692	529.1	.76
La Paz	Villazon	921	690.5	.75
Cochabamba	Charana	661	515.7	.78
Cochabamba	Ollague	706	542.6	.77
Cochabamba	Villazon	935	690.5	.74
Oruro	Charana	411	340.9	.83
Oruro	Ollague	444	367.8	.83
Oruro	Villazon	673	515.7	.77
Santa Cruz	Yacuiba	539	421.6	.78
Santa Cruz	Corumba	651	502.2	.77
Future connections (1990)				
Cochabamba	Santa Cruz	555	433.*[b]	.78
Santa Cruz	Mamore river	348	271.*	.78

[a] Source: Based on statistics provided by ENFE, La Paz, Bolivia, 1979.

[b] Assuming a rate of $b.78 per MT per Km.

Table 36. Aircraft conversion costs[a] ($b)

Concept	Unit of measurement	Unit cost ($b)	Total cost ($b)
Auxiliary generator[b]			60,000
Air conditioning[b]			40,000
Insulation (2" urethane board)[c]	sq. ft.	27	20,331
Aluminum beans (2" diameter)[d]	linear ft.	44	28,864
Aluminum sheating (.032" thick)[e]	sq. ft.	31	23,531
Bolts, hooks, etc.[b]			12,500
Labor[b]			15,000
Unforeseen (5%)			10,011
Total			$b 210,237

[a]Corresponds to a C-46 type of aircraft.

[b]These costs have been doubled from the study by Hunting and Vivado, 1973.

[c]Sarviel, et al. 1980.

[d]Godfrey, 1980, p. 214.

[e]Godfrey, 1980, p. 132.

recovery period, an annual rate of interest equal to 10 percent, a 500 Kg. loss (because of the additional weight of the refrigeration equipment and insulation materials), a cruising speed of 300 Km./hour, and 55 flying hours per month, an additional air transportation cost of \$b .0012/Kg./Km. can be obtained.[1] This figure has been adjusted upwards to allow for operating and maintenance expenses of the refrigerating equipment. Consequently, the total cost of transportation for type "H" beef in refrigerated aircraft is \$b .0038/Kg./Km.

Truck It is not an easy task to estimate transportation costs for cattle and beef along the future road connections. Costs for cattle shipments can be estimated from truck tariffs prevailing in existing routes. However, this is not possible for beef transportation in refrigerated trucks because this mode is still not existent in the country. Beef transport costs are dependent upon various factors, such as the quality of the roads, the characteristics of the traffic, the types of vehicles, the institutional arrangements, the extent of government support, and the nature of public regulation. Better constructed or maintained roads tend to lower vehicle maintenance costs, and permit higher traveling speeds, which can result in reduced transport costs if they are not offset by increased user charges. The size, age, and fuel efficiency of the vehicles

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[1]The calculation is as follows: \$b 210,237 x .40211 = \$b 84,538. Annual payment on investment. \$b 84,538 ÷ (55 hrs. x 301 Km./hr.) (4,500 Kgs.) = \$b .00113/Kg./Km.

employed will also affect transport costs. Traffic characteristics such as the volumes being transported, the availability of return cargo, and the turnaround time have an impact upon shipping costs.

Because of the inadequate nature of roads in Bolivia, Hunting and Vivado (1973, p. 324) have recommended that trucks intended to transport meat in Bolivia must be of conventional type (straight trucks) and not trailers nor semi-trailers, and must have a distance between axles no greater than 200 inches.

In refrigerated trucks, because carcasses must be transported hanging, the center of gravity of the moving vehicles is at a higher level, and consequently they must travel at slower speeds. Hunting and Vivado (1973, p. 324) report that refrigerated trucks, carrying ten tons of meat, make the 903 Km. journey between La Paz and Santa Cruz in 40 hours, at an average speed of 25 Km. per hour, which is almost one-half of the speed at which a normal truck travels along that route.

The Bolivian transportation sector is characterized by certain monopolistic features. For example, JUNAC (April 1978, p. 59) reports that, in the city of Cochabamba, an entity has been organized which is in charge of transporting cattle from Beni sources, through Puerto Villaroel, and supplying goods to river communities all the way down to Puerto Almacen. This entity groups truck and barge operators and prevents the entry of competing firms. This type of monopolistic control prevails along the principal routes of the country. Because transport unions contain numerous and vocal

Table 37. Refrigerated truck transportation: capital and operating costs[a] ($b)

Concept	Amount
Capital costs	
Purchase of a 22' long straight truck, diesel powered, with a 270 Detroit engine, 7-speed transmission, radial tires and tandem wheels in the U.S.	1,540,300
Purchase of a Thermoking refrigeration unit in the U.S.	500,000
Shipping and insurance	100,000
Total cost CIF La Paz	2,140,300
Operating and maintenance costs	
Maintenance Thermoking unit[b]	25.0/hour
Maintenance truck	1.5/Km
Fuel	3.0/Km
Driver	50.0/hour
Insurance	25,000.0/year

[a] Most of these figures were obtained from the Iowa Motor Truck Association. Des Moines, 1980.

[b] Assuming maintenance is not done in centralized shops, for in this case, maintenance costs would be halved.

individuals, they usually can exert sufficient lobbying pressure to obtain and retain monopolistic privileges in the routes of their selection. Given the key role played by these transport unions, it seems logical that live cattle and beef transportation arrangements be established jointly by the government, the truckers, the producers, and the wholesalers to determine the types of industry structure, vehicles, rates, and regulation.

For analytical purposes, it will be assumed that an institutional arrangement is established in which truckers are free to enter into any one of the routes to be opened, their decision being based solely upon expected net returns. Under these circumstances, an individual trucker confronts the capital and operating costs presented in Table 37.

Assuming that a refrigerated truck operates 270 days/year, 10 hours/day, at an average speed of 25 Km./hour, it travels 67,500 Km./year, its capital and operating costs are as indicated in Table 38.

Table 38. Refrigerated truck transportation: annual capital and operating costs ($b/year)

Concept	Amount
Capital costs	348,333
Insurance costs	25,000
Maintenance of refrigerating unit	67,500
Maintenance of truck	101,250
Fuel	202,500
Driver	135,000
Total	879,583

If the truck transports an average payload of 7,000 Kgs. (70 percent of total capacity), the transport cost of beef will be approximately $b .0019 per Kg. per Km.

Table 39 presents type "H" beef transport costs in the various modes available. Time loss has been estimated adopting a procedure similar to the one used for estimating time loss for cattle in transit. Time loss and shrinkage estimates are assumed to be the same for all modes. Note the very low railroad rates in comparison to the other modes.

The transport costs shown in Table 39 reflect a clear advantage of rail transport over the other modes. As Table 40 indicates, railroad transportation is the cheapest one for distances longer than 200 Km. Air transportation is cheaper than truck transportation for distances shorter than 300 Km. This is so because, during the first hours after slaughter, the speed of air transportation in the shorter routes prevents costly carcass shrinkage.

Table 41 shows the minimum cost transport costs of high quality beef between each pair of regions, considering the completed 1990 transportation infrastructure. These costs are assumed to be the same in either direction. Most of the entries in this table refer to air transportation. Truck transportation prevails only in entry (15, 12), while rail transportation is used in entries (15, 13), (15, 14), (16, 13), (16, 14), and (16, 15).

Consequently, if the 1980 transportation infrastructure is

Table 39. Type "H" beef transport costs

Concept	Mode		
	Railroad	Airplane	Truck
Out-of-pocket costs ($b/Kg./Km.)	.00078	.0038	.0019
Time losses in transit[a] ($b/carcass/day)		1.75	
Shrinkage[b,c]	$b 32/carcass/hour during the first 4 hours; $b 64/carcass/day afterwards.		

[a] Represents the interest lost by the cash equivalent of one 200 Kg. beef carcass ($b 6,400), that would have been earned if deposited in a bank.

[b] From JUNAC, April 1979, Anexo 4, and assuming a price per Kg. of $b 32.

[c] The speeds employed are the following: railroad and truck, 25 Km./hour; airplane (C-46), 300 Km./hour.

Table 40. Comparative transport costs of type "H" beef ($b/Kg/Km)

Distance (Km)	Mode: Railroad	Airplane	Truck
20	.16	.09	.20
50	.36	.22	.41
80	.54	.35	.66
100	.72	.43	.83
200	.86	.87	1.08
300	.99	1.30	1.38
400	1.12	1.73	1.56
500	1.25	2.16	1.92
800	1.60	3.46	2.88
1,000	2.08	4.33	3.52
1,200	2.57	5.20	3.91

Table 41. Type "H" beef transport costs (1990 transportation infrastructure)

Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1																		
2	.22																	
3	1.01	.74																
4	1.06	.86	.33															
5	2.15	1.94	1.31	1.14														
6	1.29	1.15	1.61	1.39	1.92													
7	1.13	.97	1.38	1.16	1.75	.23												
8	.95	.85	1.46	1.30	2.04	.37	.34											
9	.80	.58	.68	.49	1.41	.93	.70	.81										
10	.28	.09	.90	.87	1.92	1.05	.87	.75	.53									
11	.45	.34	1.09	1.01	1.98	.85	.69	.52	.58	.25								
12	.48	.48	1.29	1.22	2.18	.87	.77	.51	.78	.40	.21							
13	1.67	1.79	2.43	2.29	3.00	1.12	1.24	1.00	1.80	1.60	1.36	1.20						
14	1.19	1.34	2.19	2.17	3.15	1.55	1.56	1.23	1.75	1.30	1.17	.97	1.01					
15	1.38	1.56	2.20	2.35	3.47	2.52	2.45	2.15	2.18	1.66	1.76	1.58	2.02	1.14				
16	2.98	3.05	3.81	3.67	4.31	2.40	2.59	2.37	3.26	2.95	2.71	2.55	1.23	1.88	2.73			
17	5.85	5.73	5.91	5.58	5.48	4.54	4.82	4.87	5.33	5.60	5.40	5.49	5.14	6.04	6.76	4.31		
18	2.15	1.94	1.31	1.14	.20	1.92	1.76	2.04	1.41	1.93	1.99	2.19	3.00	3.15	3.47	4.33	5.57	

considered, only these latter six entries are changed, being replaced by air transport costs. Air transportation costs for these routes are as follows: \$b 1.69, \$b 2.35, \$b 1.38; \$b 1.38, \$b 1.96, and \$b 3.26 per Kg. of high quality beef, respectively.

CHAPTER VIII. COMPUTATION AND RESULTS

Optimal type "H" slaughterhouse locations and beef-cattle flows were obtained using two sets of transport costs and four different type "H" beef export scenarios. One set of transport costs of beef and cattle corresponds to the completed transportation infrastructure, which includes all the connections existing by 1980, plus those to be completed in the course of the 1980s, namely the roads from La Paz to Trinidad and to Riberalta; from Cochabamba to Trinidad and to Santa Cruz; and from San Ramon to Trinidad; and the railroads from Cochabamba to Santa Cruz; and from Santa Cruz to Rio Mamore. The other set of transport costs correspond to the transportation infrastructure existing by 1980, without any of the previously mentioned new linkages.

Three export scenarios consider one of the foreign destinations (regions 16, 17 and 18) as the only export outlet for high quality Bolivian beef, while the fourth scenario considers that the export surplus of type "H" beef is allocated equally among the three foreign market outlets. Table 42 presents the manner in which these scenarios have been labeled.

Scenario A.1

In the first run of the program, every slaughterhouse within Bolivia was assigned a maximum slaughter capacity of 10,400,000 Kgs. per year, and the corresponding total average processing costs of

Table 42. Transportation - beef export scenarios

Destinations of high quality beef exports	Transportation infrastructure 1980	1990
Only region 16	A.1	A.2
Only region 17	B.1	B.2
Only region 18	C.1	C.2
Regions 16, 17, and 18 (equal volumes each)	D.1	D.2

\$b 1.29/Kg. (see Table 25). Demand for type "H" beef in region 16 was set equal to 39,154,000 Kgs. Assuming that Bolivia does not seek to export live cattle but only high quality beef, slaughter capacities in regions 16, 17, and 18 were all set at zero. The minimum cost solution yielded a value of \$b 256,259,975 and the type "H" beef slaughter levels shown in Table 43.

Table 43. Results of the first program run (scenario A.1)

Region	Volume of type "H" beef (Kgs.)	Region	Volume of type "H" beef (Kgs.)
1	10,339,000	9	-
2	1,779,000	10	-
3	3,443,000	11	-
4	5,300,800	12	2,900,000
5	1,785,800	13	10,400,000
6	1,580,600	14	5,056,000
7	0	15	8,466,800
8	3,891,000		

Given the activity levels shown in Table 43, the slaughter plants in regions 7, 9, 10, and 11 were eliminated. For the remaining plants, slaughter costs and capacities were adjusted in a manner consistent with the processing levels obtained in the first program run. The following processing costs were introduced: P2 = 2.80; P3 = 2.68; P4 = 1.98; P5 and P6 = 2.80; P8 = 2.32; P12 = 2.56; P14 = 1.98; and P15 = 1.49. The following annual processing capacities were entered: in regions 2, 5, and 6, 1,560,000 Kgs.; in regions 3, 4, 8, and 14, 5,200,000 kgs.; and in region 12, 3,120,000 Kgs. At this stage, care was taken to select, in borderline cases, the smallest possible plant size, once aggregate processing capacity was sufficient to process the total volume of type "H" beef demanded.

The second run of the model yielded a minimum cost solution of \$b 284,564,089 and the regional slaughter levels shown in Table 44.

Table 44. Results of the second program run (scenario A.1)

Region	Volume of type "H" beef (Kgs.)	Region	Volume of type "H" beef (Kgs.)
1	10,400,000	9	-
2	725,800	10	-
3	3,443,000	11	-
4	5,200,000	12	3,120,000
5	884,200	13	10,400,000
6	1,031,800	14	5,200,000
7	-	15	10,400,000
8	4,137,200		

The slaughter volumes presented in Table 44 required additional adjustments in processing costs, so the following new costs were introduced: P2, P5 = 4.84; P6 = 3.91; and P12 = 2.36. With these new prices, a new minimum cost solution equal to $b 285,001,788 was obtained, associated with the slaughter levels shown in Table 45.

Table 45. Results of the third program run (scenario A.1)

Region	Volume of type "H" beef (Kgs.)	Region	Volume of type "H" beef (Kgs.)
1	10,400,000	9	-
2	-	10	-
3	5,022,000	11	-
4	5,200,000	12	3,120,000
5	-	13	10,400,000
6	-	14	5,200,000
7	-	15	10,400,000
8	5,200,000		

As a consequence of the results in Table 45, those plants in regions 2, 5 and 6 were eliminated. However, processing costs for regions 3 and 8 needed adjustment, namely to P3, P8 = 1.98 and P15 = 1.49. With the introduction of these new processing costs, a minimum cost solution equal to $b 277,638,387 was found, which indicated the slaughter levels, plant locations and sizes presented in Table 46.

Table 46. Type "H" plants - number, locations, sizes and outputs (scenario A.1)

Region	Slaughter level (Kgs.)	Installed capacity (Kgs.)	Internal rent ($b/Kg.)
1	10,400,000	10,400,000	.99
3	5,166,000	5,200,000	-
4	5,200,000	5,200,000	.93
8	5,200,000	5,200,000	.11
12	3,120,000	3,120,000	.11
13	10,400,000	10,400,000	1.36
14	5,056,000	5,200,000	.34
15	10,400,000	10,400,000	.04
Total	54,942,000	55,120,000	

Consequently, under this export framework, the following slaughterhouse investment patterns are suggested: build plants, with a processing capacity of 200 head per day each, in regions 1, 13 and 15; build plants with a processing capacity of 100 head/day in regions 3, 4, 8, and 14; and build a plant with a slaughter capacity of 60 head per day in region 12. This location pattern of type "H" slaughterhouses and the corresponding beef shipments by air are shown in figure 15.

The internal rent column in Table 47 is obtained from the dual activity information of the rows section provided by the MPSX output. These internal rents correspond to the λ_{16} variables of the dual linear program presented in Chapter VI. Note that region 13 has the highest internal rent and region 15 the lowest.

The previous optimal solution for type "H" slaughterhouses is

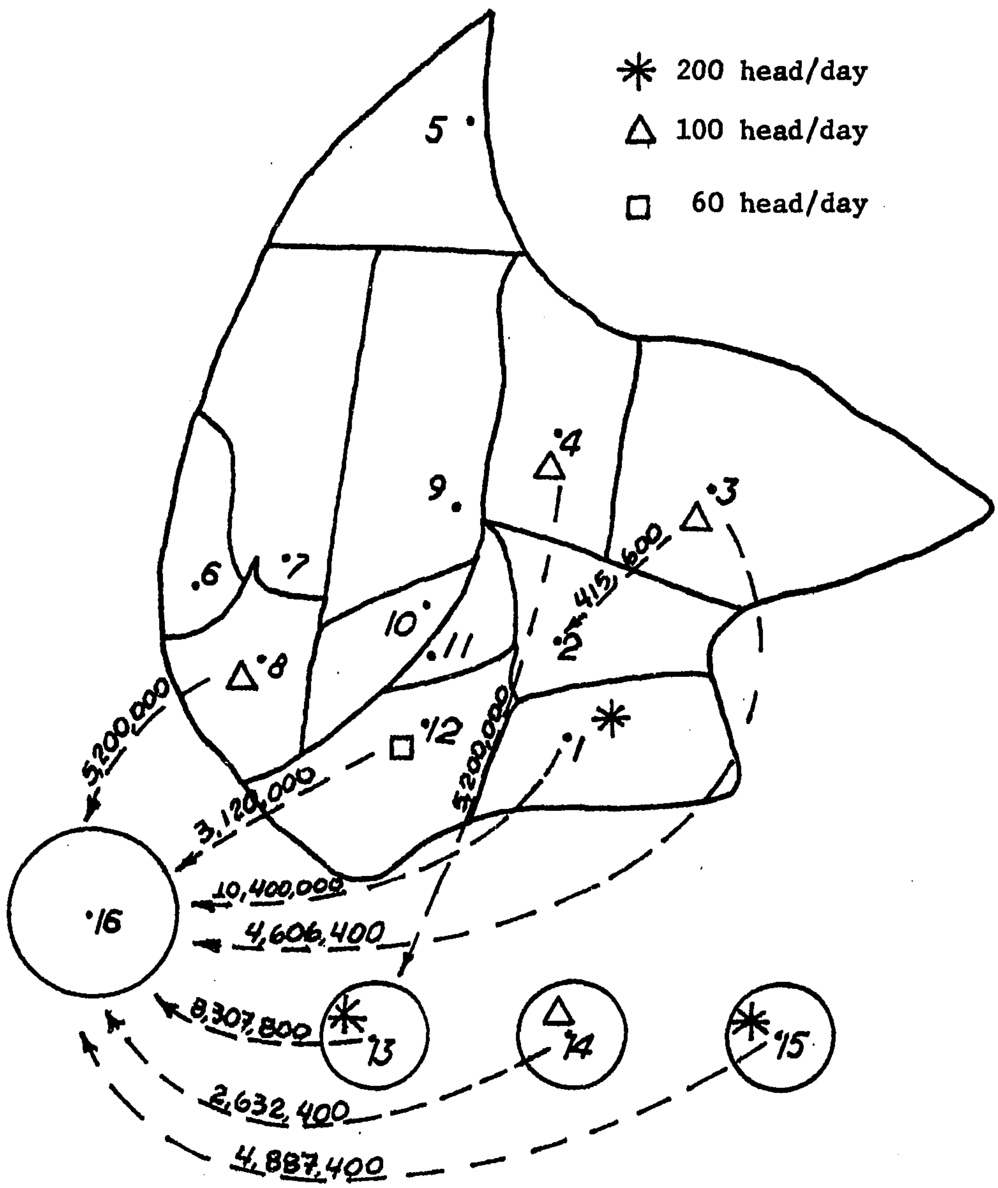

Figure 15. Type "H" slaughterhouse locations and type "H" beef flows - scenario A.1

associated with the processing levels in type "L" plants presented in Table 47.

Table 47. Type "L" plants - processing levels (scenario A.1)

Region	Volume of type "L" beef (Kgs.)	Region	Volume of type "L" beef (Kgs.)
1	1,326,000	9	10,608,000
2	10,608,000	10	3,978,000
3	6,477,800	11	8,160,800
4	6,630,000	12	830,000
5	-	13	5,902,000
6	1,580,600	14	5,449,000
7	6,162,000	15	9,082,800
8	-		

The type "L" beef flows corresponding to the levels of processing shown in Table 47 are presented in Figure 16. Note that region 2 specializes in the production of type "L" beef, and is the main supplier of region 15. Type "H" beef demand in region 2 is satisfied with imports from region 3. Region 8 does not employ its installed type "L" processing capacity, but produces only type "H" beef for export to region 16. Regions 6, 7, 9, 10, and 11 produce only type "L" beef.

Figure 17 shows live cattle flows. Note that the major live cattle flows originate in region 5 (which does not possess slaughter facilities) and in region 2, and that these flows occur only between regions in Beni.

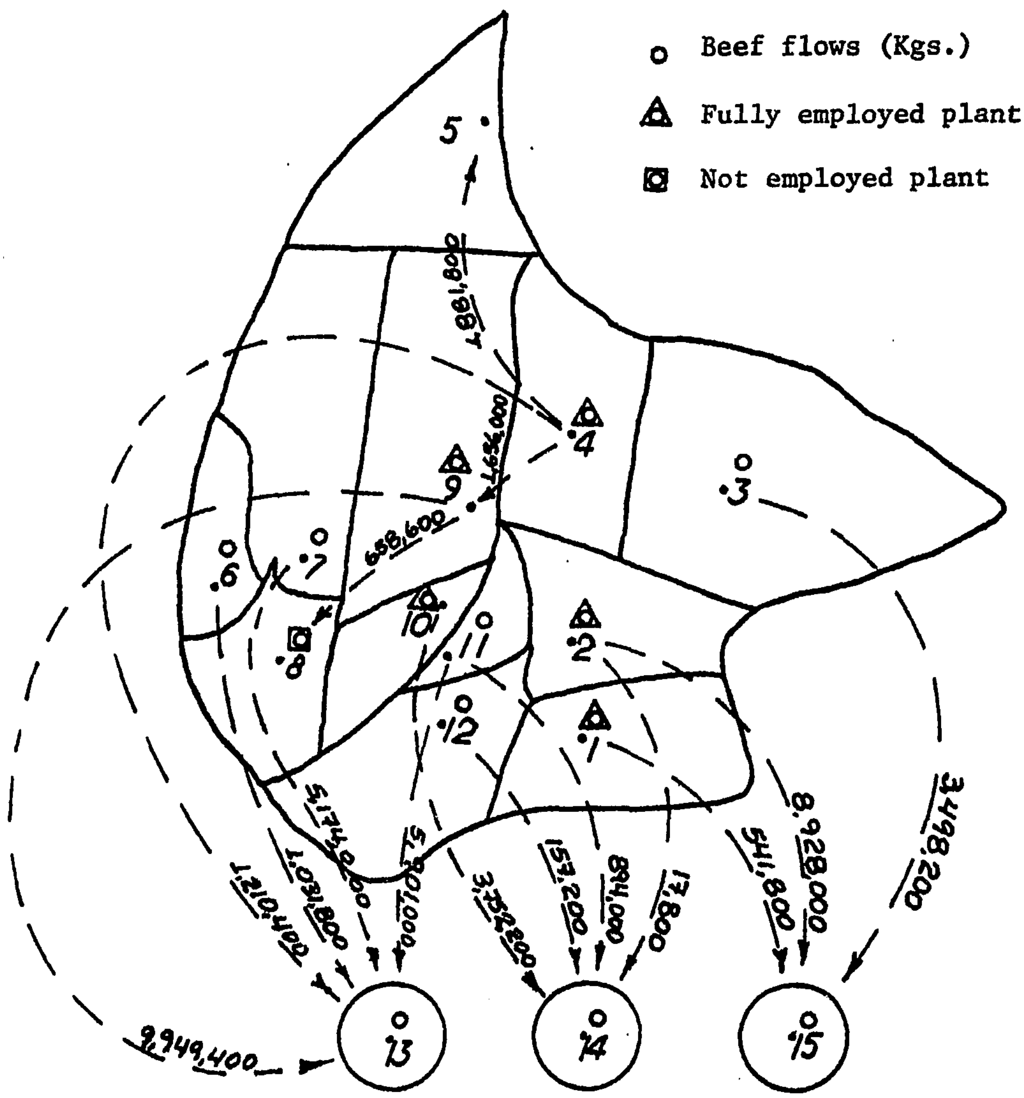

Figure 16. Type "L" beef flows - scenario A.1

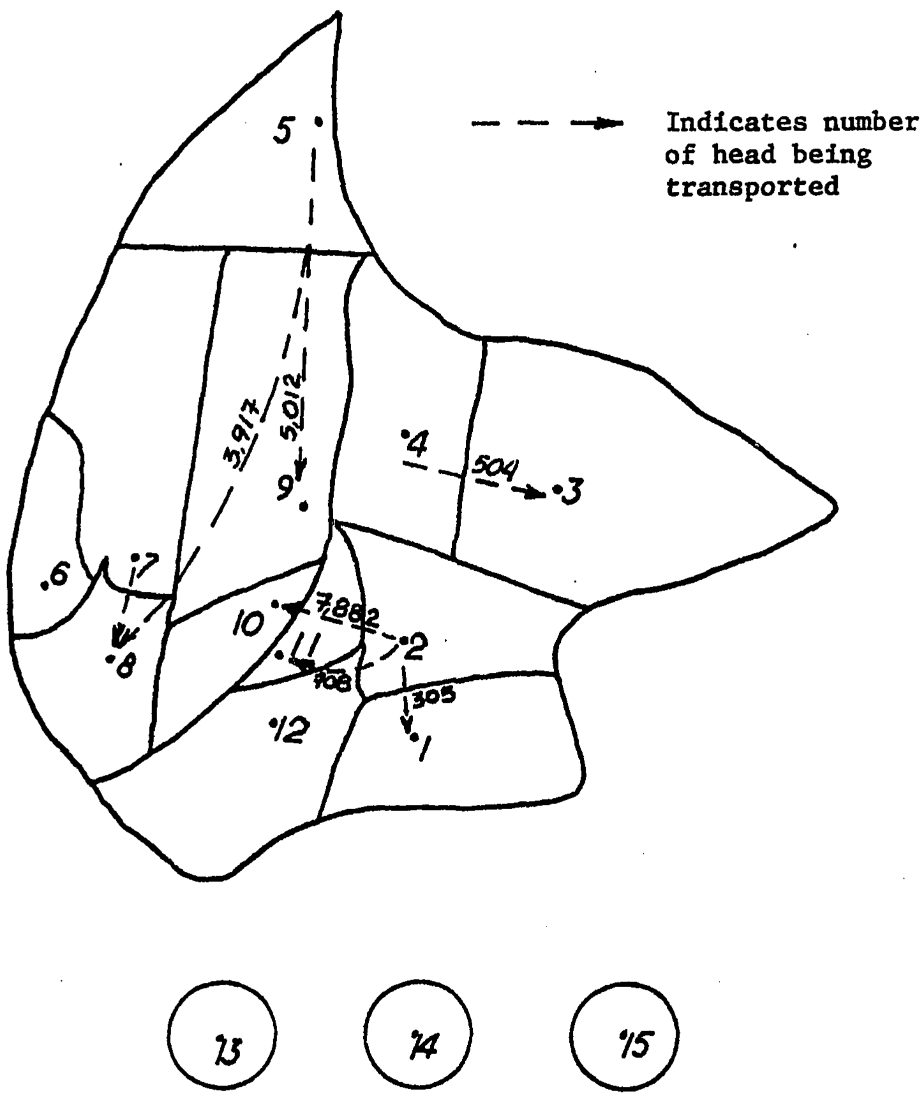

Figure 17. Live cattle flows - scenario A.1

Scenario A.2

Using the same iterative procedure employed in scenario A.1, a minimum cost solution of $b 277,161,975 was found. This solution is 476,412 (.17 percent) lower than that corresponding to scenario A.1. The pattern of slaughterhouse sizes, numbers, sites, and output levels associated with scenario A.2, turned out to be identical to the one for scenario A.1. However, internal rents of type "H" slaughterhouses in some regions changed as a result of the new transport linkages. In particular, the internal rents to slaughter operations in regions 1, 8, 12, and 13 increased, while that corresponding to region 14 was reduced to zero. The largest internal rent was associated also with region 13 ($b 1.54/Kg.) and the lowest with region 15 ($b .04/Kg). The completed transport infrastructure also causes some minor changes in type "H" beef flows. Specifically, volumes shipped from regions 3 and 14 to 16 are reduced; the volume transported from region 13 to 16 increases; and there is a new flow from region 3 to 13 (figure 18). These changes in beef flows respond to the substitution of air transportation by cheaper rail services in the routes between regions 13 and 16, and between regions 14 and 16.

Processing levels of type "L" beef at each location with the exception of regions 3 and 14 remain unchanged. Region 3 processes 144,000 Kgs. more and region 14 reduces its output by the same amount. Figure 19 shows the flows of type "L" beef. The flows from region 9 to 8 and from 2 to 14 are eliminated; the flows from 3 to 15, 4 to 13, and 11 to 14 decrease; the flows from 11 to 13, 9 to 13,

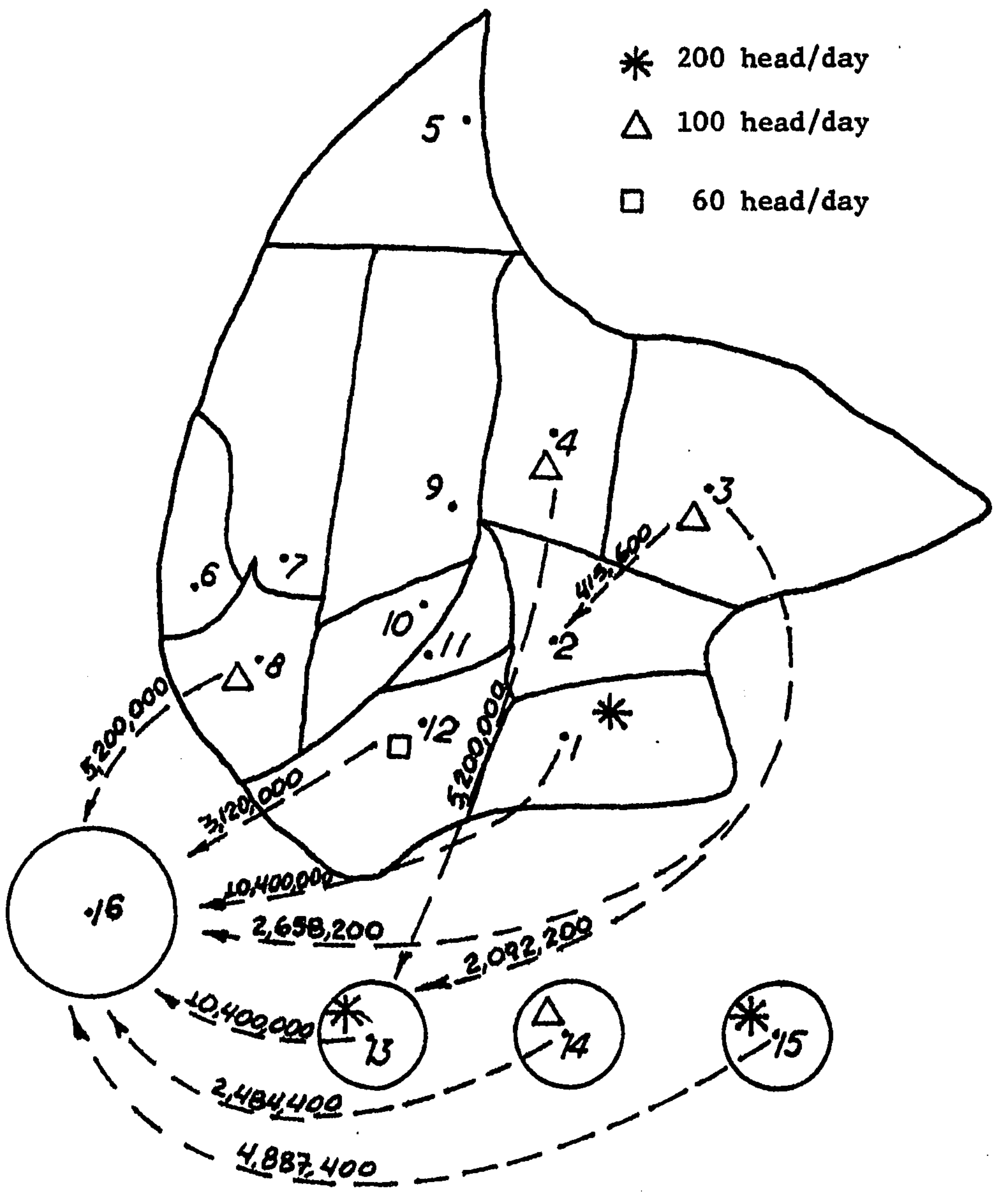

Figure 18. Type "H" slaughterhouse locations and type "H" beef flows - scenario A.2

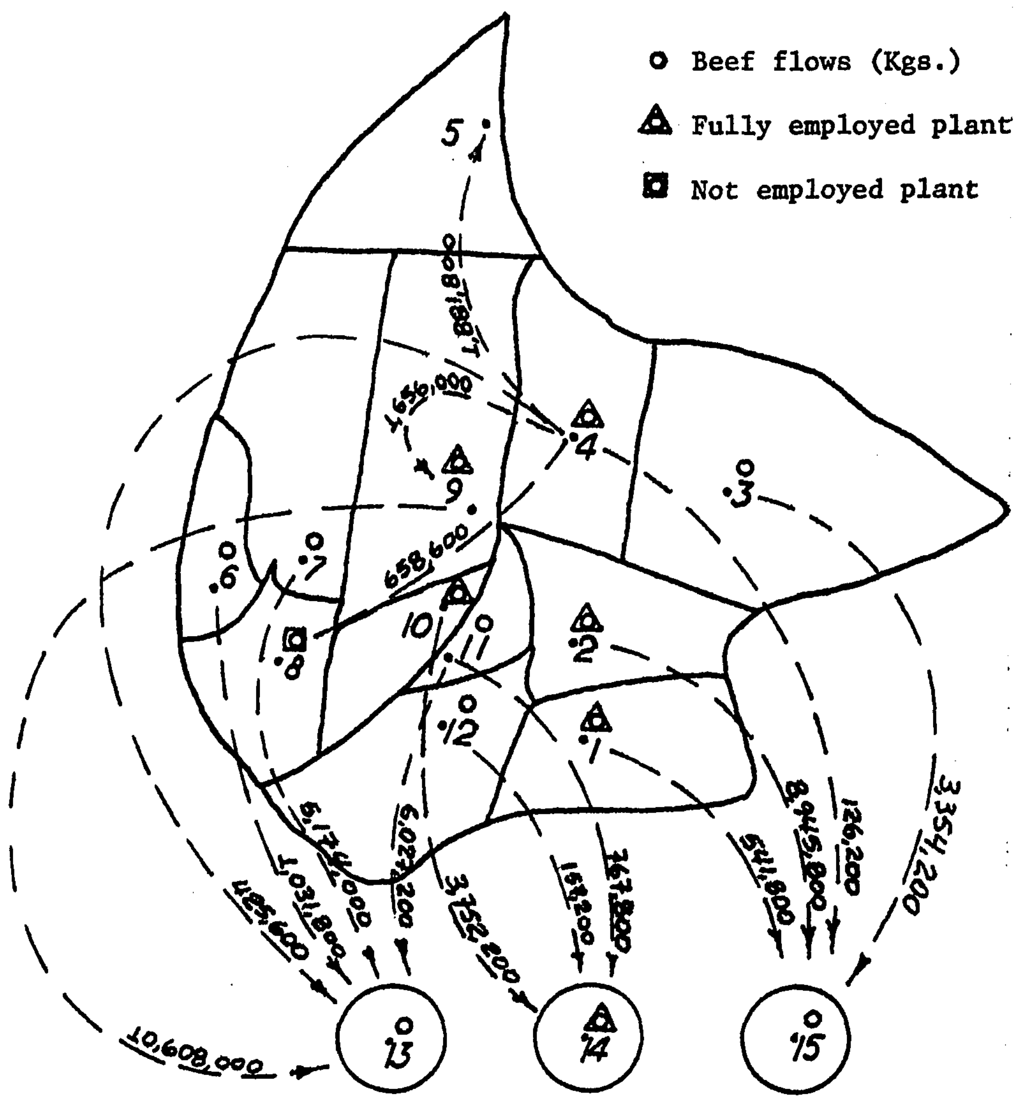

Figure 19. Type "L" beef flows - scenario A.2

and 2 to 15 increase, and there are new flows from 4 to 15 and to 8. The completed transportation infrastructure does not cause any change in live cattle flows.

Scenario B.1

After six iterations, a minimum cost solution of \$b 373,318,468 was obtained. Note that this sum is about one-third higher than that one corresponding to scenario A.1. This is so because the central point of region 17, Lima, is located at a considerably greater distance from regions within Bolivia than Arica in region 16. This solution is associated with the slaughterhouse location pattern presented in Table 48. Note that the highest internal rents occur in regions 4 and 7.

Table 48. Type "H" plants - number, locations, sizes, and outputs (scenario B.1)

Region	Slaughter level (Kgs.)	Installed capacity (Kgs.)	Internal rent (\$b/Kg.)
1	10,400,000	10,400,000	+ .86
4	10,400,000	10,400,000	+1.75
7	10,400,000	10,400,000	+1.02
9	5,200,000	5,200,000	+ .93
13	5,012,200	5,200,000	-
14	5,056,000	5,200,000	-
15	8,466,800	10,400,000	-
Total	54,942,000	57,200,000	

The location pattern presented in Table 48 and the associated type "H" beef flows are shown in Figure 20. All of these beef flows employ air transportation. With the exception of the type "H" beef from region 1 to 2, the entire output of Beni high quality beef is exported to region 17.

Figure 21 presents the air transported type "L" beef flows associated with the location pattern of type "H" slaughterhouses shown in Table 48. Processing levels in type "L" plants are presented in Table 49.

Table 49. Type "L" plants - processing levels (scenario B.1)

Region	Volume of type "L" beef (Kgs.)	Region	Volume of type "L" beef (Kgs.)
1	1,326,000	9	3,510,800
2	10,608,000	10	3,978,000
3	7,956,000	11	8,160,800
4	4,973,800	12	3,950,000
5	-	13	11,282,800
6	548,800	14	5,593,000
7	-	15	11,016,000
8	3,891,000		

Note that region 7 specializes in the production of high quality beef, and produces no type "L" beef. Region 2 specializes in the production of low quality beef, being the main supplier of regions 14 and 15.

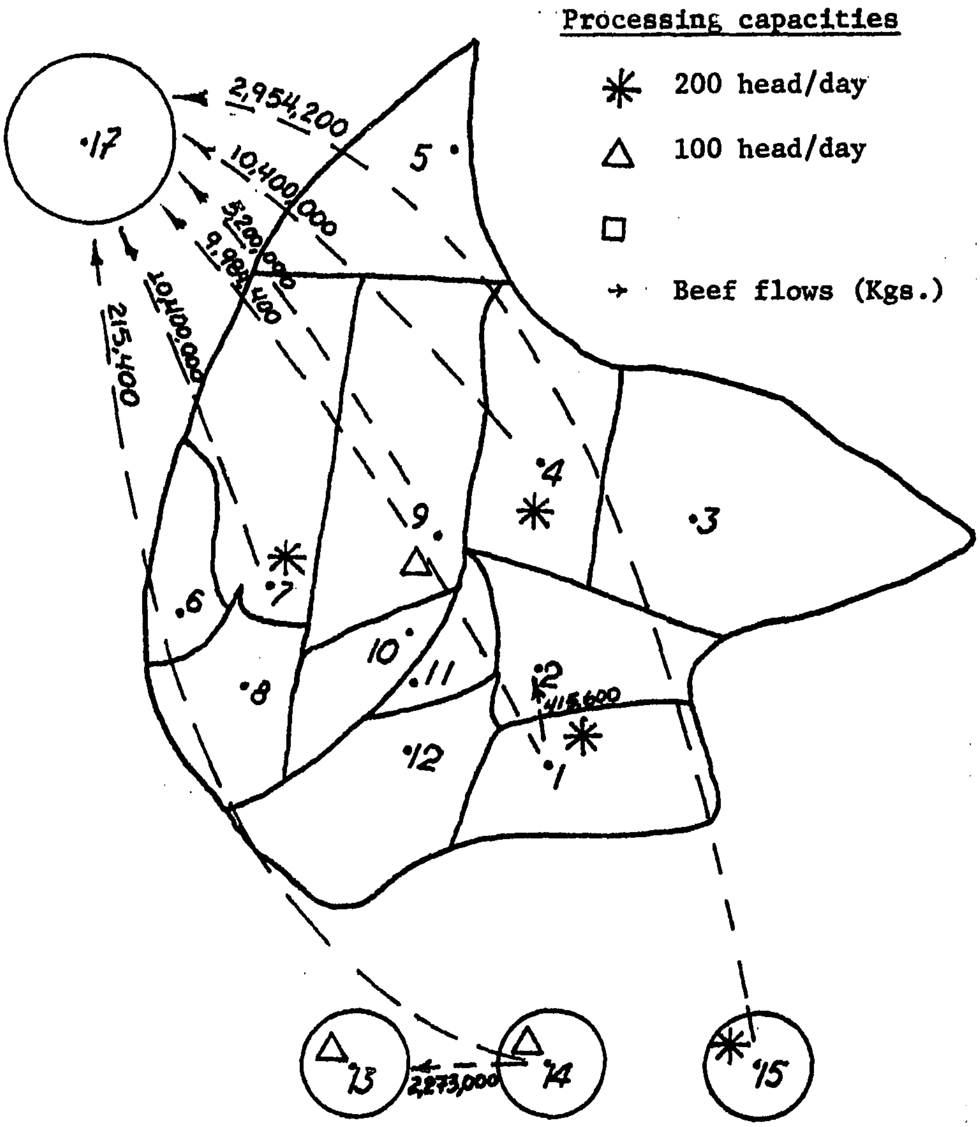

Figure 20. Type "H" slaughterhouse location, and type "H" beef flows - scenario B.1

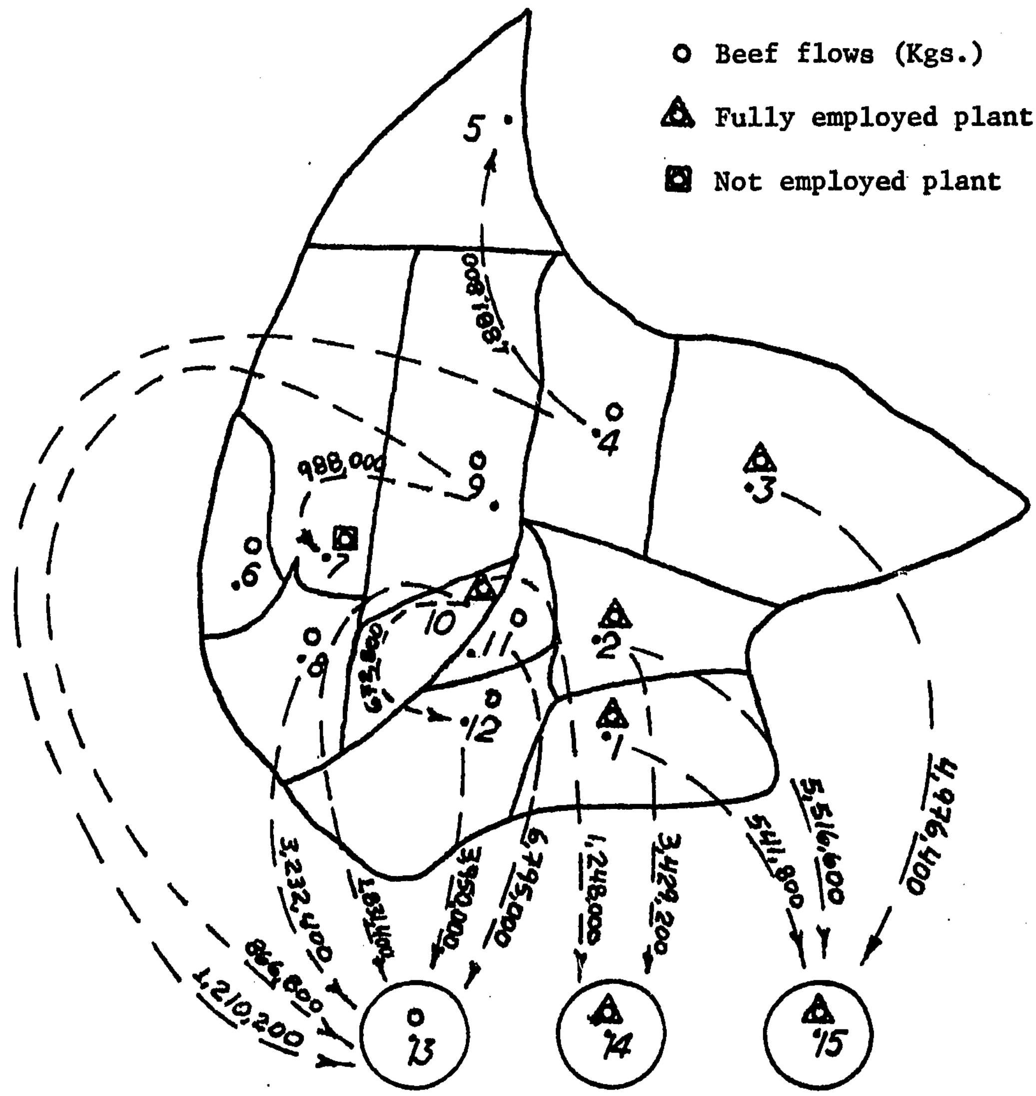

Figure 21. Type "L" beef flows - scenario B.1

Figure 22 presents the live cattle flows that correspond to the output levels and slaughterhouse locations shown in Tables 48 and 49.

Scenario B.2

A minimum cost solution equal to \$b 372,199,479 was found. This solution is \$b 1,118,989 (.30 percent) lower than that corresponding to scenario B.1. The slaughterhouse location pattern associated with such minimum cost solution is indicated in Table 50.

Table 50. Type "H" plants - number, locations, sizes, and outputs (scenario B.2)

Region	Slaughter level (Kgs.)	Installed capacity (Kgs.)	Internal rent (\$b/Kg.)
4	10,400,000	10,400,000	+ .30
6	10,400,000	10,400,000	+ .40
7	5,448,300	10,400,000	-
9	10,400,000	10,400,000	+ .28
13	4,770,900	5,200,000	-
14	5,056,000	5,200,000	-
15	8,466,800	10,400,000	-
Total	54,942,000	62,400,000	

The location pattern shown in Table 50 and the related type "H" beef flows are shown in Figure 23. In relation to scenario B.1, region 6 has displaced region 1 in supplying the Lima market; the exporting plant in region 9 has increased in size to the maximum capacity; exports from region 14 to Lima have ceased; region 15 has replaced

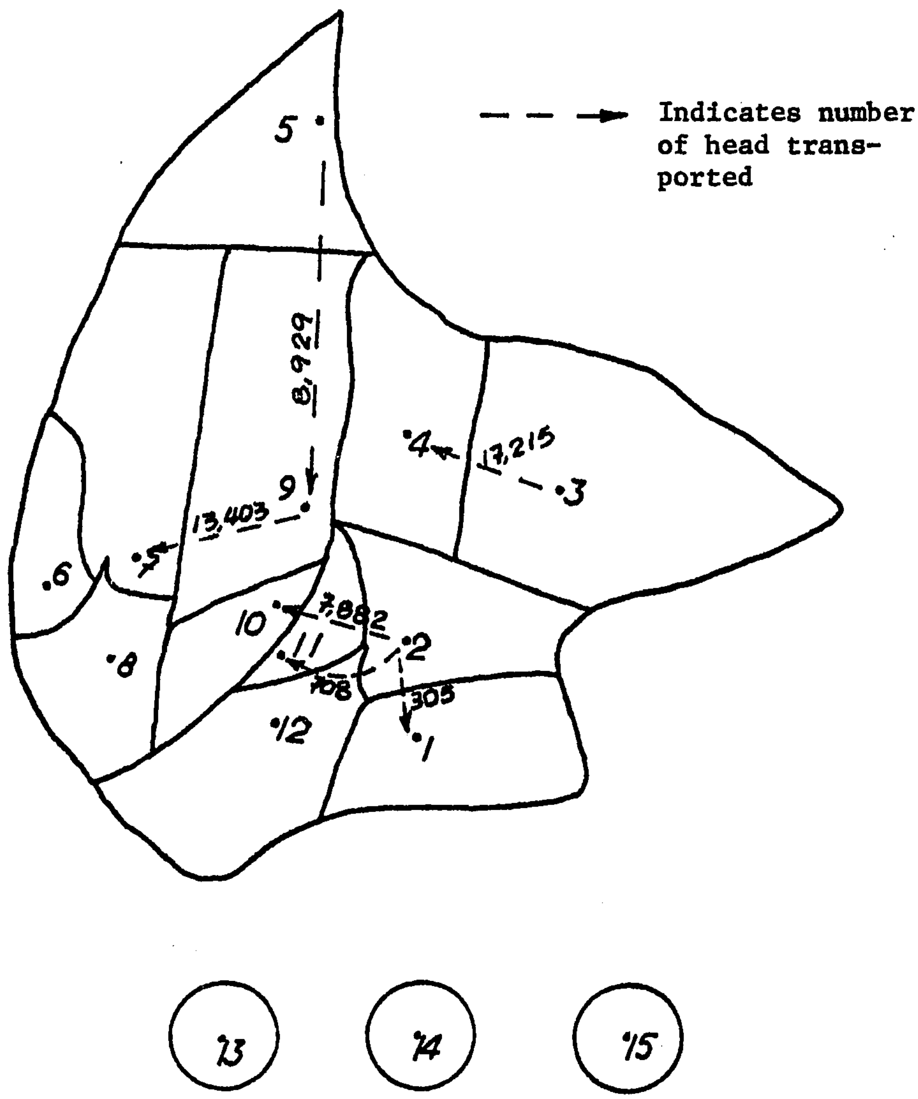

Figure 22. Live cattle flows - scenario B.1

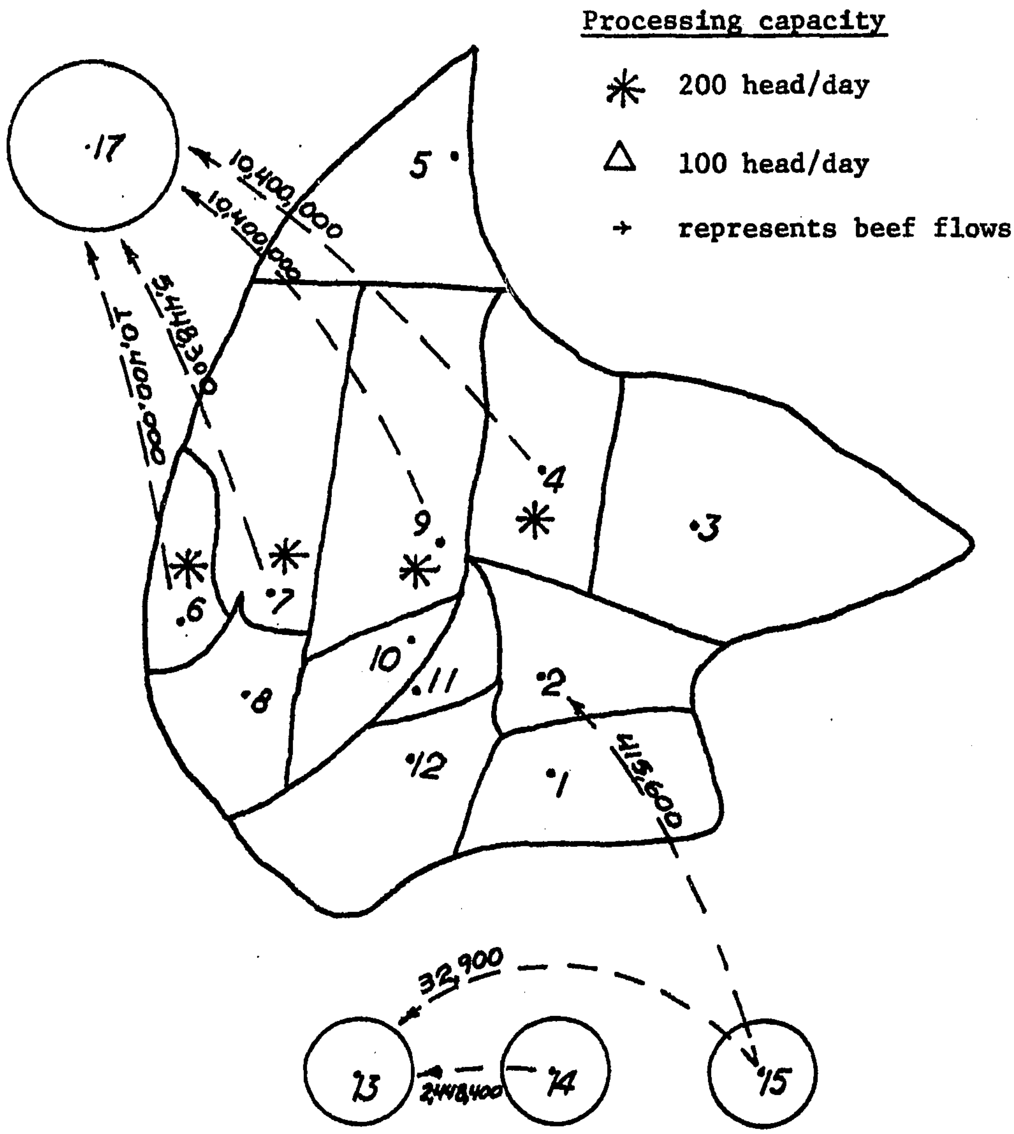

Figure 23. Type "H" slaughterhouse locations and type "H" beef flows - scenario B.2.

region 1 in supplying Trinidad; due to a reduced plant size, exports from region 7 to Lima have been reduced significantly; and the product flows from regions 14 to 13, 15 to 17 and 15 to 13 show minor changes. Several differences can be noticed between the internal rent columns of tables 48 and 50. The internal rents of the plants in regions 4, 7, and 9, are lowered with the completed transport infrastructure. In the case of region 7, its internal rent is reduced to zero.

With the exception of the new flow from region 15 to 13, which employs rail transport, all other type "H" beef flows in scenario B.2 use air transportation. The new flow by rail, which is relatively small, is a result of the completed railroad link between Cochabamba and Santa Cruz.

Type "L" processing levels corresponding to scenario B.2 are shown in Table 51.

Table 51. Type "L" plants - processing levels (scenario B.2)

Region	Volume of type "L" beef (Kgs.)	Region	Volume of type "L" beef (Kgs.)
1	1,326,000	9	991,400
2	10,608,000	10	3,978,000
3	7,956,000	11	9,741,400
4	4,973,800	12	3,950,000
5	-	13	11,531,100
6	-	14	5,593,000
7	1,239,300	15	11,016,000
8	3,891,000		

The product flows associated with the processing levels indicated in Table 51 are presented in figure 24. Various differences in relation to scenario B.1 can be noted: region 4 does not export type "L" beef to region 13, but rather to region 9; region 6 specializes in producing type "H" beef and must import low quality beef from region 7; exports from region 9 to 7 and 13, and from 12 to 13 decrease; exports from regions 10 and 11 to 13 increase, while those from region 10 to 12 are reduced to zero; and there is a new flow from region 7 to 6.

Figure 25 shows the related live cattle flows. Note the large new live cattle flow from region 1 to 6; the increased flow from region 2 to 11; and the absence of live cattle shipments from region 9 to 7, 2 to 1, and 6 to 7. The increased live cattle flow from region 1 to 6 is a result of completion of the La Paz-Trinidad road. The increased flows from regions 1 and 2 to 11 respond to the completion of the Cochabamba-Trinidad road.

Scenario C.1

After three iterations, a minimum cost solution equal to \$b 202,930,368 was found, associated with the type "H" slaughterhouse location pattern presented in table 52. Note that this solution is much lower than those obtained for scenarios A.1 and B.1. This is so because the Brazilian destination (Guajara-Merim) considered in scenario C.1 is much closer to beef producing sources in Beni than Arica and Lima.

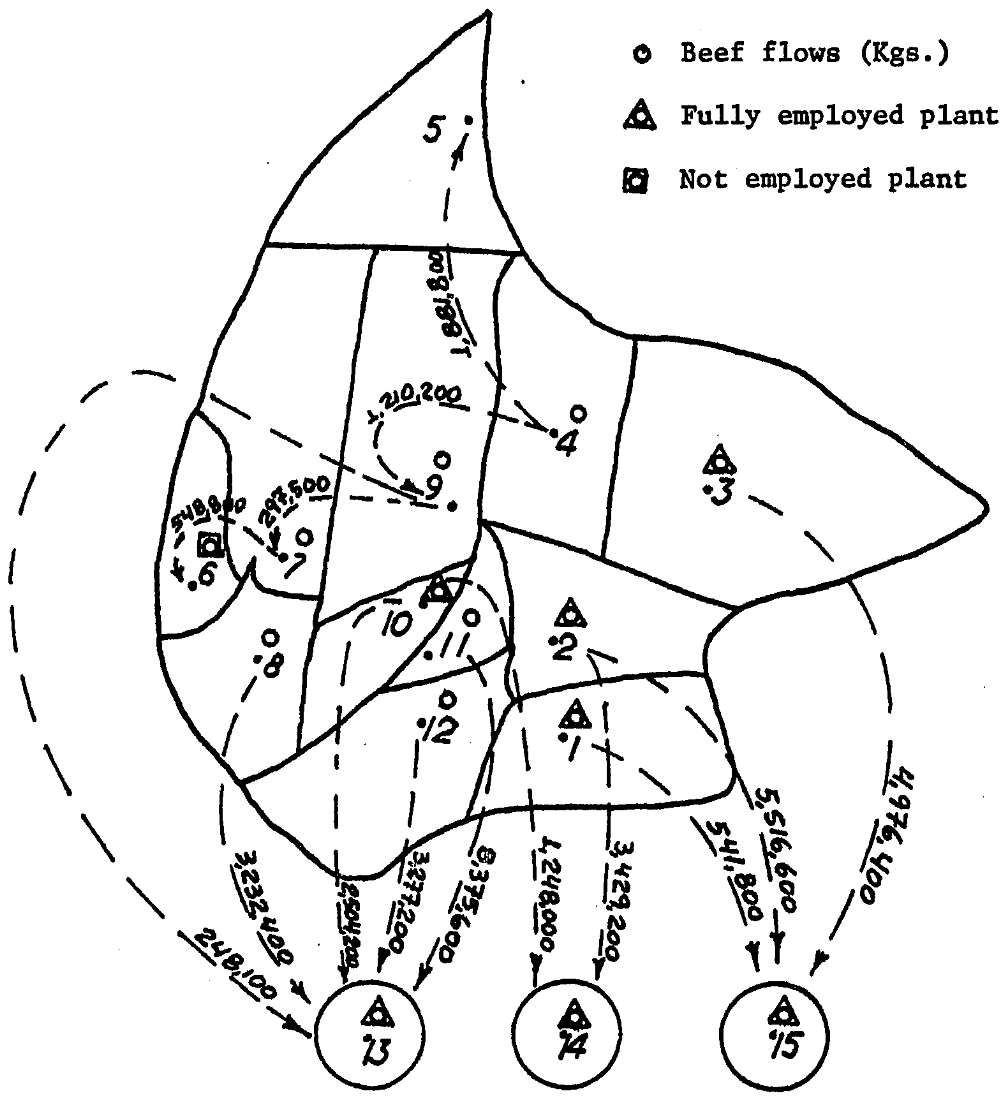

Figure 24. Type "L" beef flows - scenario B.2

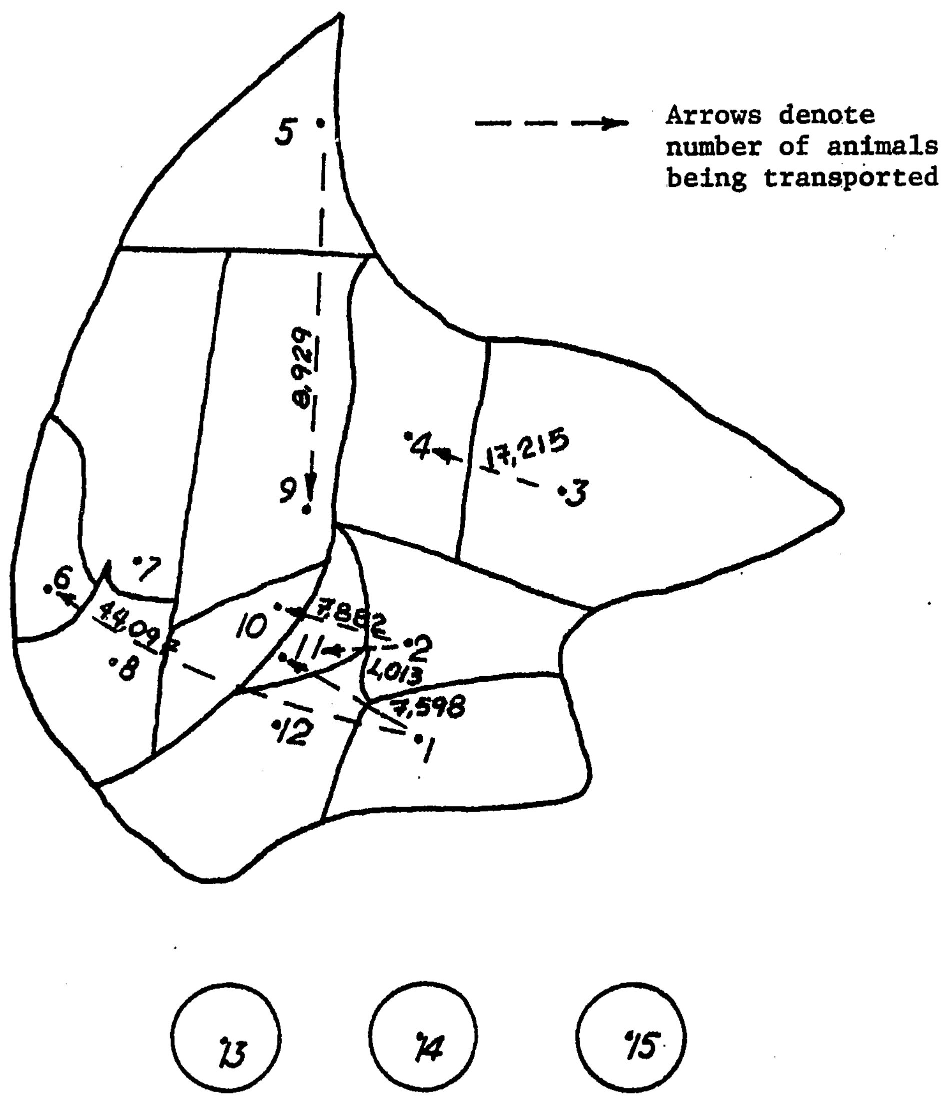

Figure 25. Live cattle flows - scenario B.2.

Table 52. Type "H" plants - number, locations, sizes and outputs (scenario C.1)

Region	Slaughter level (Kgs.)	Installed capacity (Kgs.)	Internal rent ($b/Kg.)
3	7,024,700	10,400,000	-
4	10,400,000	10,400,000	+.12
5	10,400,000	10,400,000	+.61
9	10,400,000	10,400,000	+.18
13	4,770,900	5,200,000	-
14	5,056,000	5,200,000	-
15	6,890,400	10,400,000	-
Total	54,942,000	62,400,000	

The plant location pattern indicated in Table 52 and its associated type "H" beef flows are shown in Figure 26. Regions 13 and 14 do not export any beef to region 18, and region 15 is the supplier of region 2. This location pattern is related to the processing levels in type "L" plants shown in Table 53.

Table 53. Type "L" plants - processing levels (scenario C.1)

Region	Volume of type "L" beef (Kgs.)	Region	Volume of type "L" beef (Kgs.)
1	1,326,000	9	2,494,100
2	10,608,000	10	3,978,000
3	4,374,300	11	8,234,500
4	1,530,800	12	3,950,000
5	-	13	11,531,100
6	1,580,600	14	5,593,000
7	6,687,600	15	11,016,000
8	3,891,000		

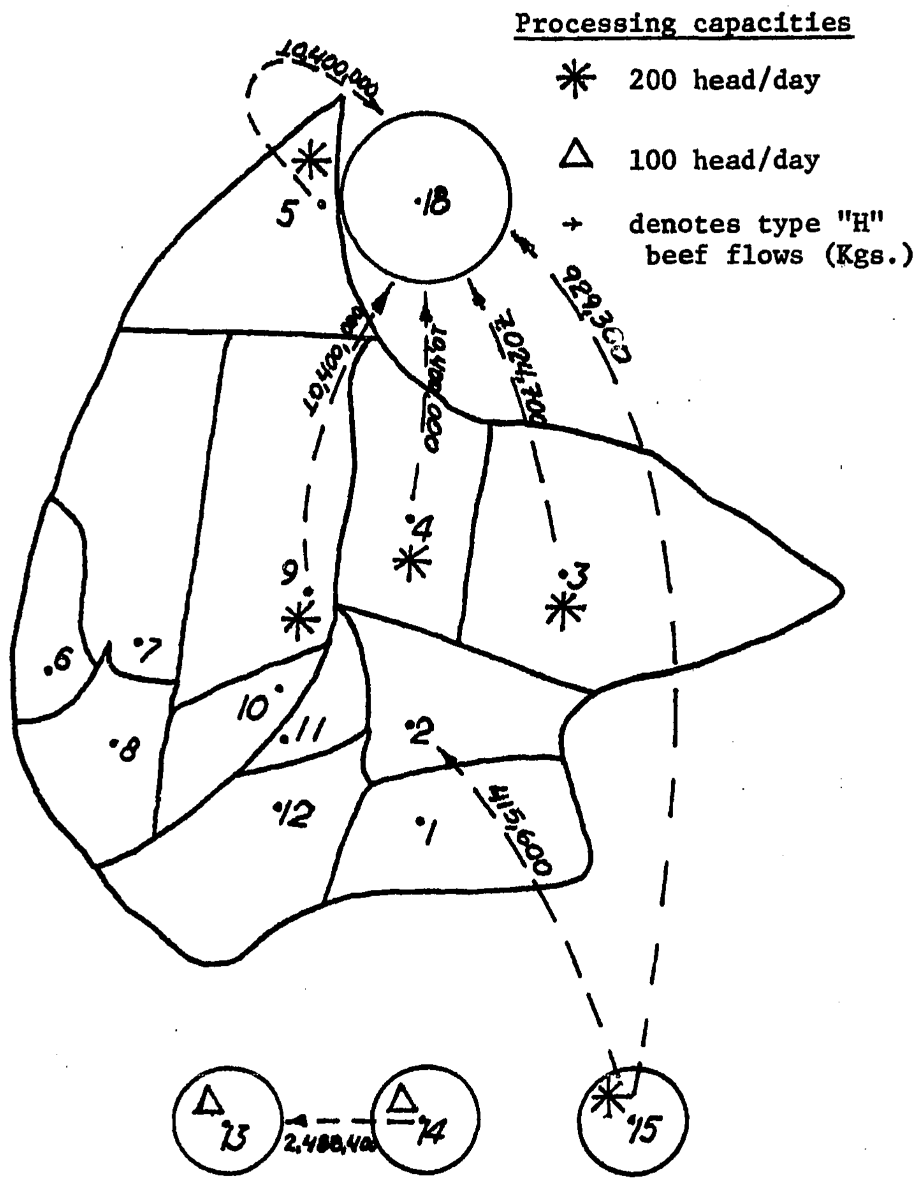

Figure 26. Type "H" slaughterhouse locations and type "H" beef flows - scenario C.1

Figure 27 shows the type "L" beef flows corresponding to scenario C.1. Region 2 has again specialized in the production of type "L" beef, the bulk of which is exported to region 15. On the other hand, regions 4 and 5 specialize in the production of type "H" beef and must import low quality beef to meet their local demands.

In relation to live cattle flows (Figure 28), note the large flow from region 15 to 10, the latter of which produces only type "L" beef for export to regions 2 and 14. This can be explained by the fact that the type "L" processing capacity in region 15 is fully employed. Another large flow originates in region 1 which supplies regions 9 and 5. Region 2 exports live cattle to region 9 instead of 10.

Scenario C.2

After two iterations, a minimum cost solution equal to $b 202,211,089 was found. This solution is $b 719,279 (.35 percent) lower than that corresponding to scenario C.1. Plant locations, output levels and beef flows associated with this scenario are presented in Table 54 and Figure 29.

Table 54. Type "H" plants - number, locations, sizes and outputs (scenario C.2)

Region	Slaughter level (Kgs.)	Installed capacity (Kgs.)	Internal rent ($b/Kgs.)
3	7,954,000	10,400,000	-
4	10,400,000	10,400,000	+ .12
5	10,400,000	10,400,000	+ .61
9	10,400,000	10,400,000	+ .09
13	4,770,900	5,200,000	-

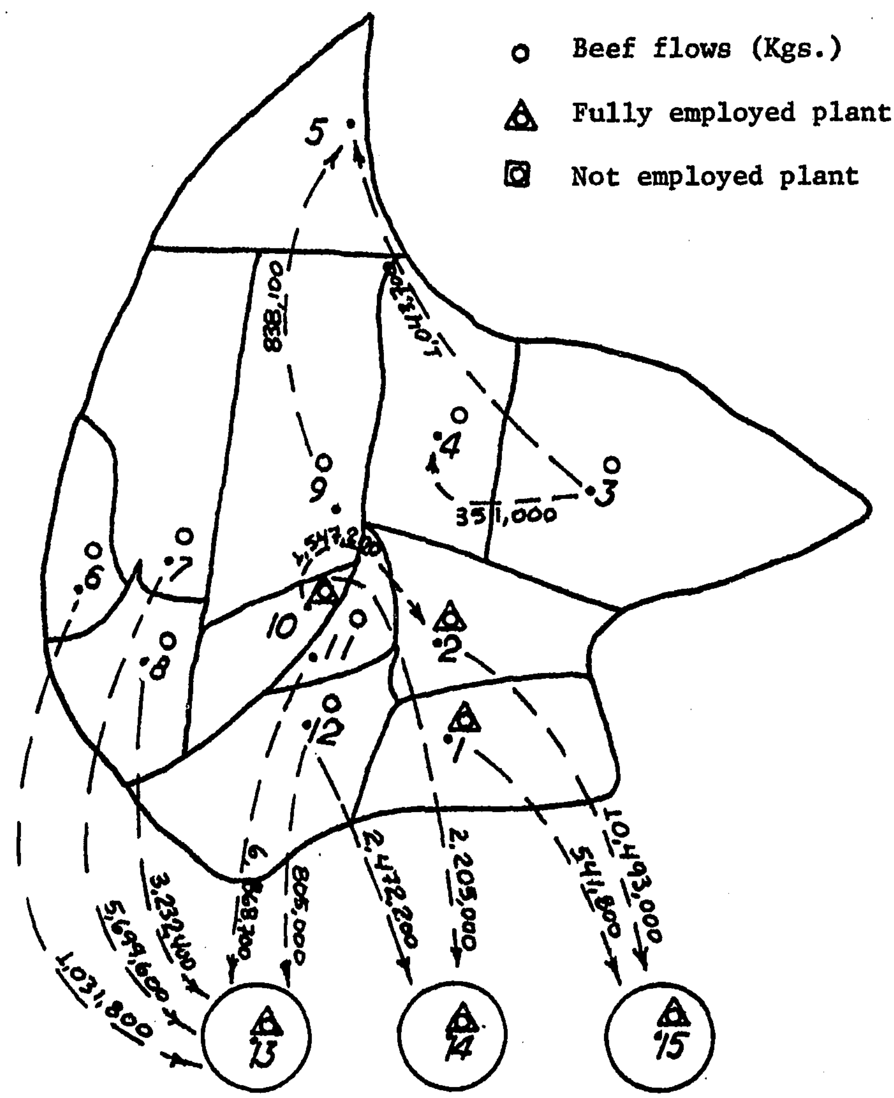

Figure 27. Type "L" beef flows - scenario C.1

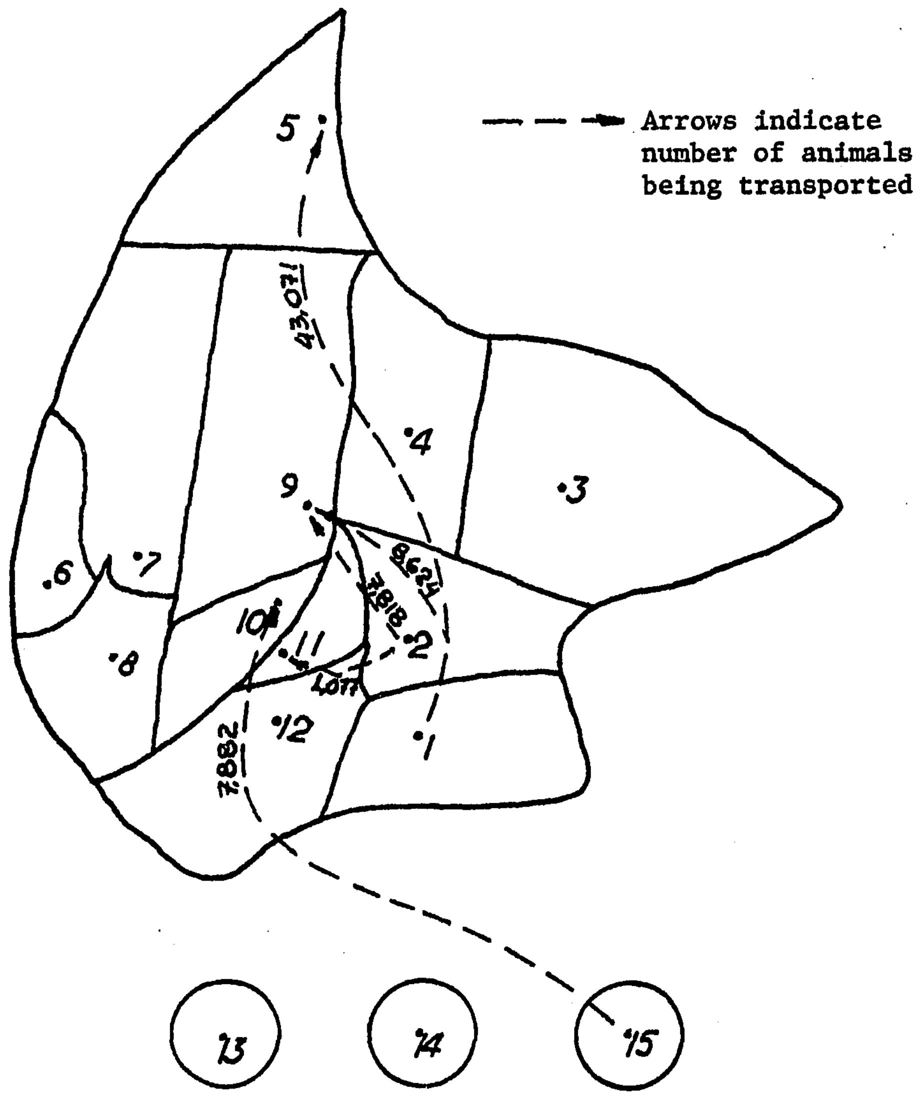

Figure 28. Live cattle flows - scenario C.1

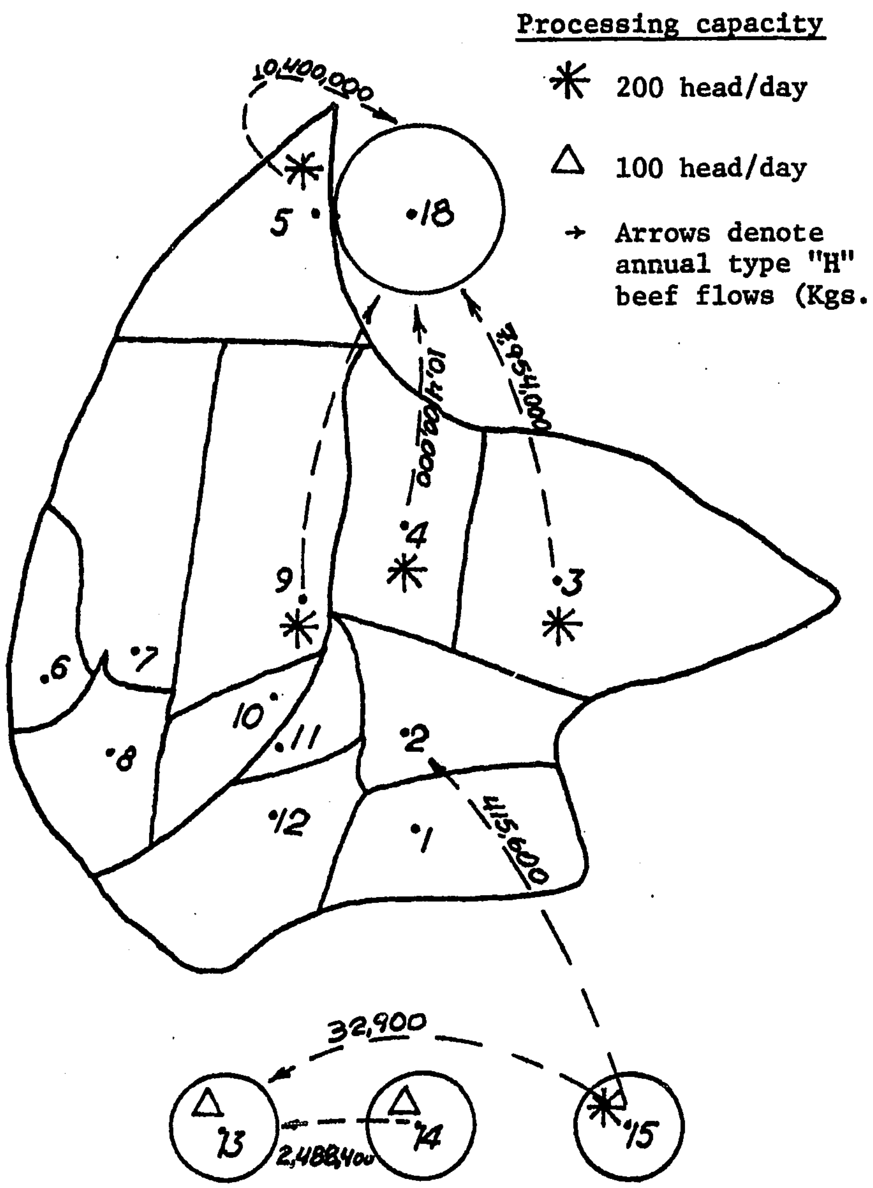

Figure 29. Type "H" slaughterhouse locations and type "H" beef flows - scenario C.2

This location pattern is essentially the same as in scenario C.1. The plant in region 15 does not export to region 18, but rather to region 13. Internal rents of processing operations in regions 4 and 5 are unchanged, and only the internal rent of the plant in region 9 is lowered.

Given the type "H" slaughterhouse location arrangement presented in Table 54, the processing levels of type "L" beef are set at the levels shown in Table 55.

Table 55. Type "L" plants - processing levels (scenario C.2)

Region	Volume of type "L" beef (Kgs.)	Region	Volume of type "L" beef (Kgs.)
1	1,326,000	9	3,423,400
2	10,608,000	10	2,401,600
3	3,445,000	11	8,019,200
4	1,530,800	12	6,455,700
5	-	13	11,531,100
6	1,580,600	14	5,593,000
7	5,973,600	15	11,016,000
8	3,891,000		

Figure 30 presents the type "L" beef flows related to the processing levels shown in Table 55. Comparing Figures 27 and 30, note that with the completed transport infrastructure various changes have taken place in type "L" beef flows: volumes shipped from regions 3 to 5, 7 to 13, 11 to 13 and 10 to 14 decrease, while those shipped

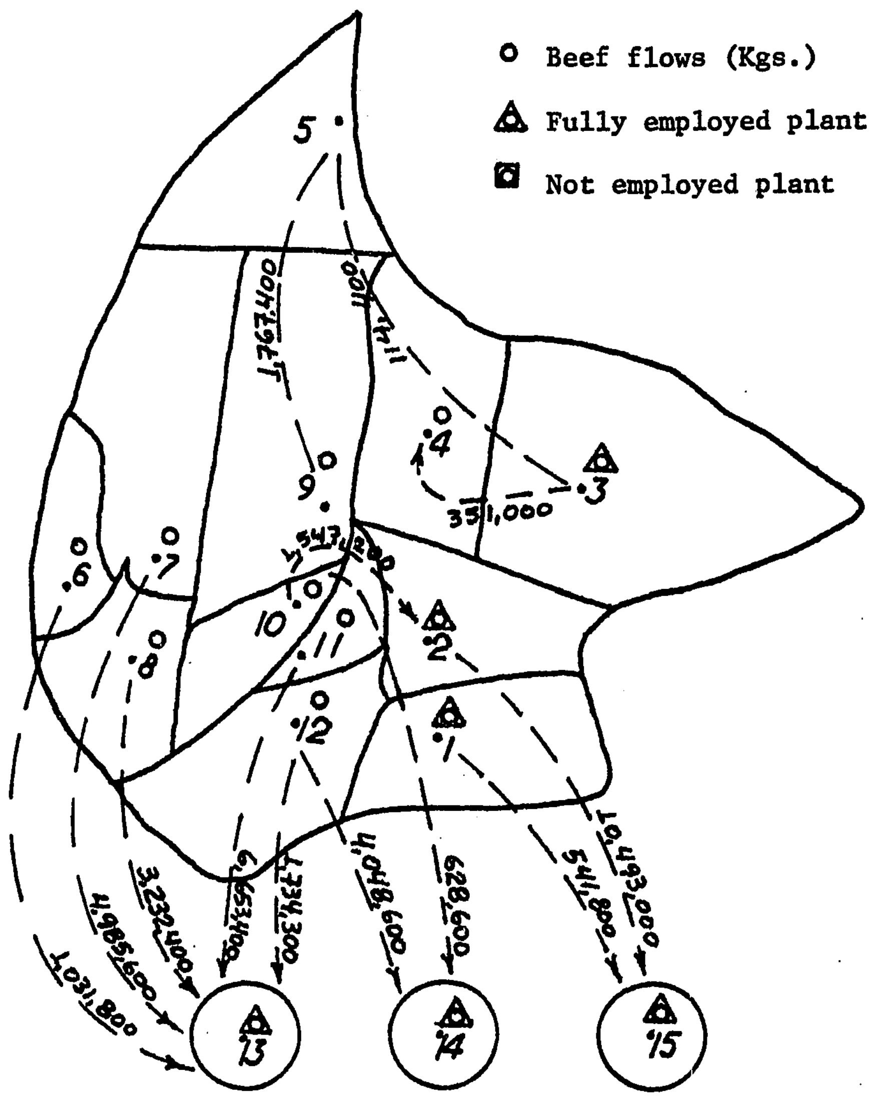

Figure 30. Type "L" beef flows - scenario C.2

from regions 9 to 5, 12 to 13 and 12 to 14 increase.

Optimal live cattle flows are presented in Figure 31. Comparing Figures 28 and 31, the new transport relationships induce a new flow of live cattle from regions 7 to 9, and 15 to 12; but eliminate the flow from region 15 to 10. The number of animals moved from region 2 to 9 increases.

The flow of live cattle from region 15 to 12 is a result of the completed Santa Cruz-Cochabamba road, through Puerto Grether. All other cattle shipments employ the 1980 transportation infrastructure.

Scenario D.1

After three iterations, a minimum cost solution equal to \$b 274,632,789 was found, associated with the plant location pattern, output levels, and beef flows shown in Table 56 and Figure 32.

Table 56. Type "H" plants - number, locations, sizes and outputs (scenario D.1)

Region	Slaughter level (Kgs.)	Installed capacity (Kgs.)	Internal rent (\$b/Kg.)
1	10,400,000	10,400,000	+ .76
3	3,120,000	3,120,000	+ .94
4	10,400,000	10,400,000	+1.39
5	1,560,000	1,560,000	+2.05
7	5,200,000	5,200,000	+ .92
9	5,200,000	5,200,000	+ .83
13	5,200,000	5,200,000	+ .51
14	5,200,000	5,200,000	+ .19
15	8,662,000	10,400,000	-
Total	54,942,000	56,680,000	

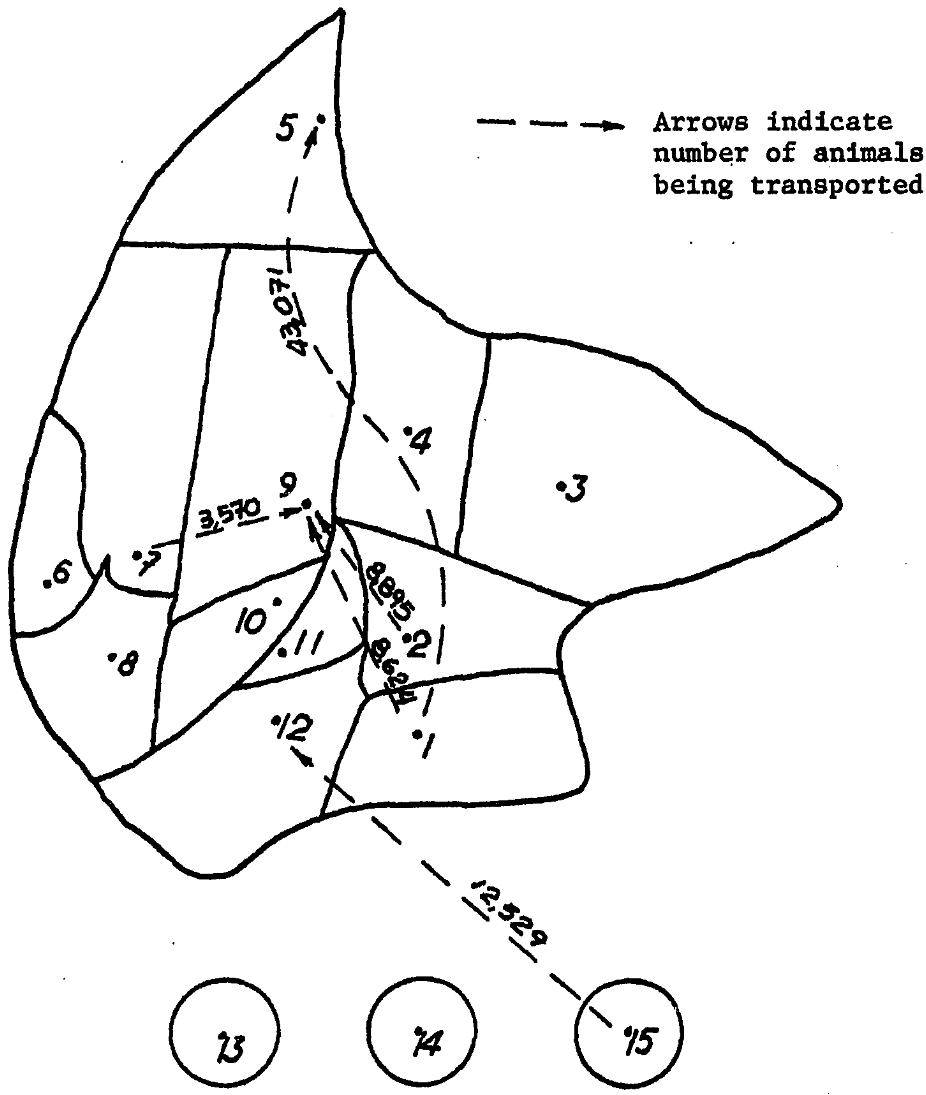

Figure 31. Live cattle flows - scenario C.2

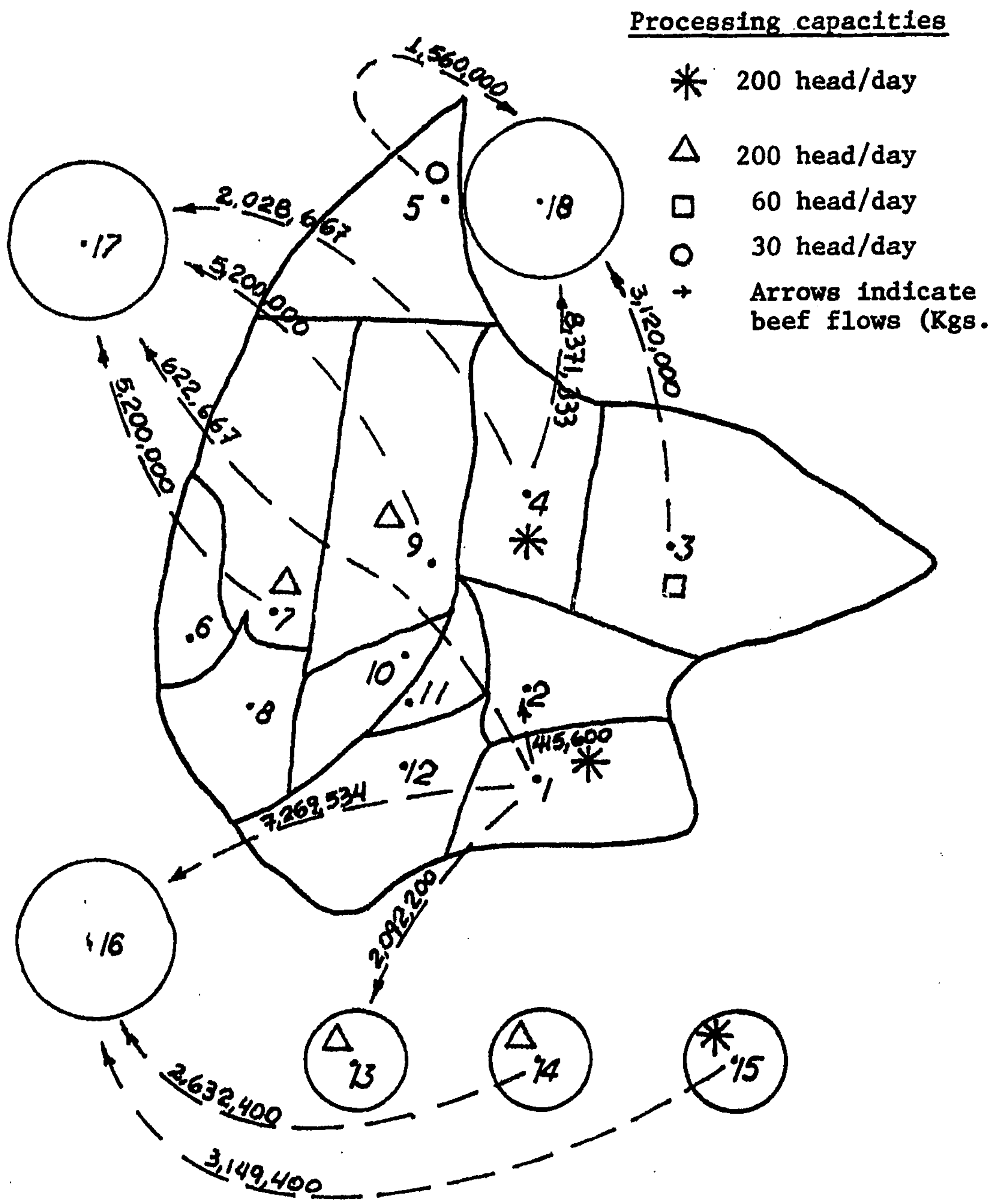

Figure 32. Type "H" slaughterhouse locations and type "H" beef flows - scenario D.1

In this scenario, the fact that various small markets must be served, rather than one large one as in the previous three situations, results in a larger number of smaller plants. Note that the highest internal rents correspond to regions 5, 4, and 3 which serve the Brazilian market.

Type "L" beef flows for this scenario are shown in Figure 33. Processing levels in type "L" plants are as shown in Table 57.

Table 57. Type "L" plants - processing levels (scenario D.1)

Region	Volume of type "L" beef (Kgs.)	Region	Volume of type "L" beef (Kgs.)
1	1,326,000	9	4,631,400
2	10,608,000	10	3,978,000
3	7,956,000	11	8,160,800
4	1,853,800	12	3,950,000
5	-	13	11,102,000
6	1,580,600	14	5,449,000
7	1,487,600	15	10,820,800
8	3,891,000		

The type "L" plants of regions 1, 2, 3, and 10 are the only ones operating at full capacity. Regions 2, 6, 8, 10, 11, and 12 specialize in low quality beef production.

The corresponding live cattle flows are presented in Figure 34. Note the much reduced numbers of cattle being transported in this scenario as compared to A.1, B.1, and C.1.

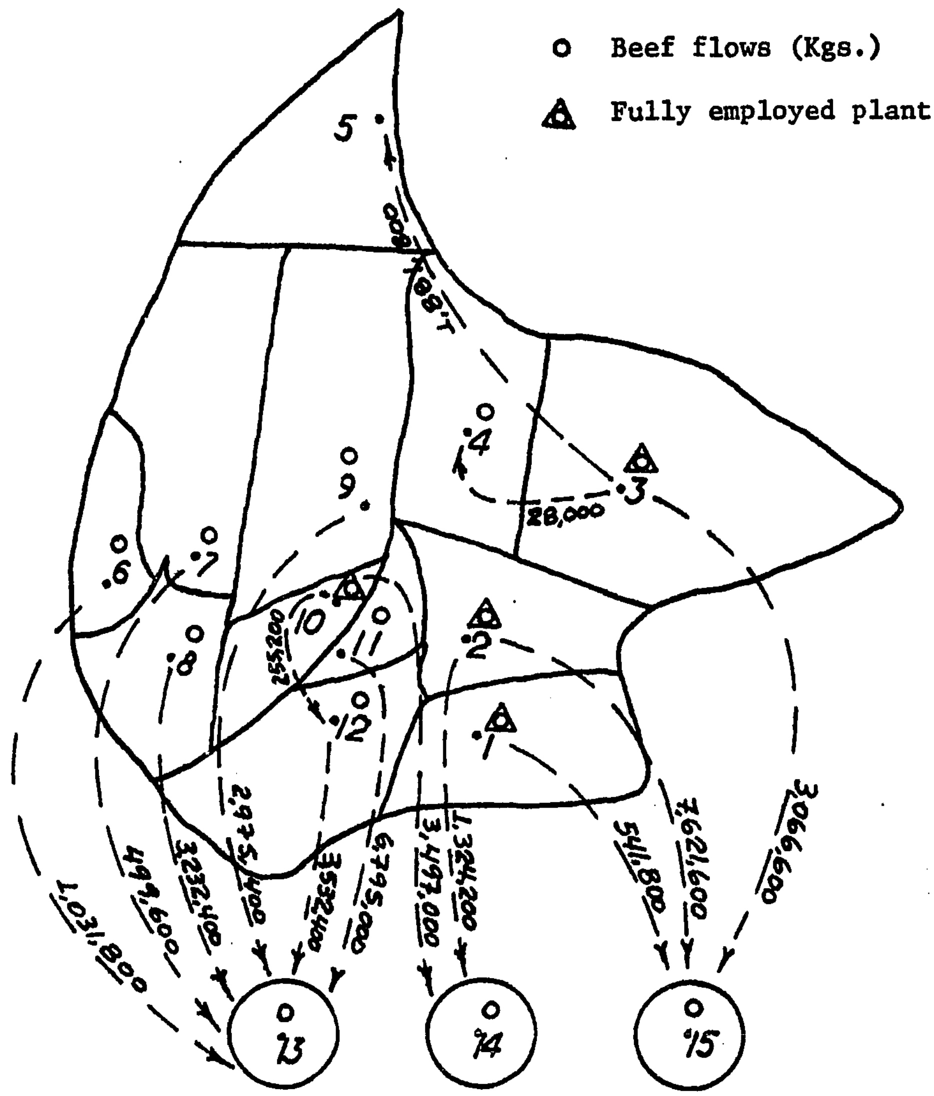

Figure 33. Type "L" beef flows - scenario D.1

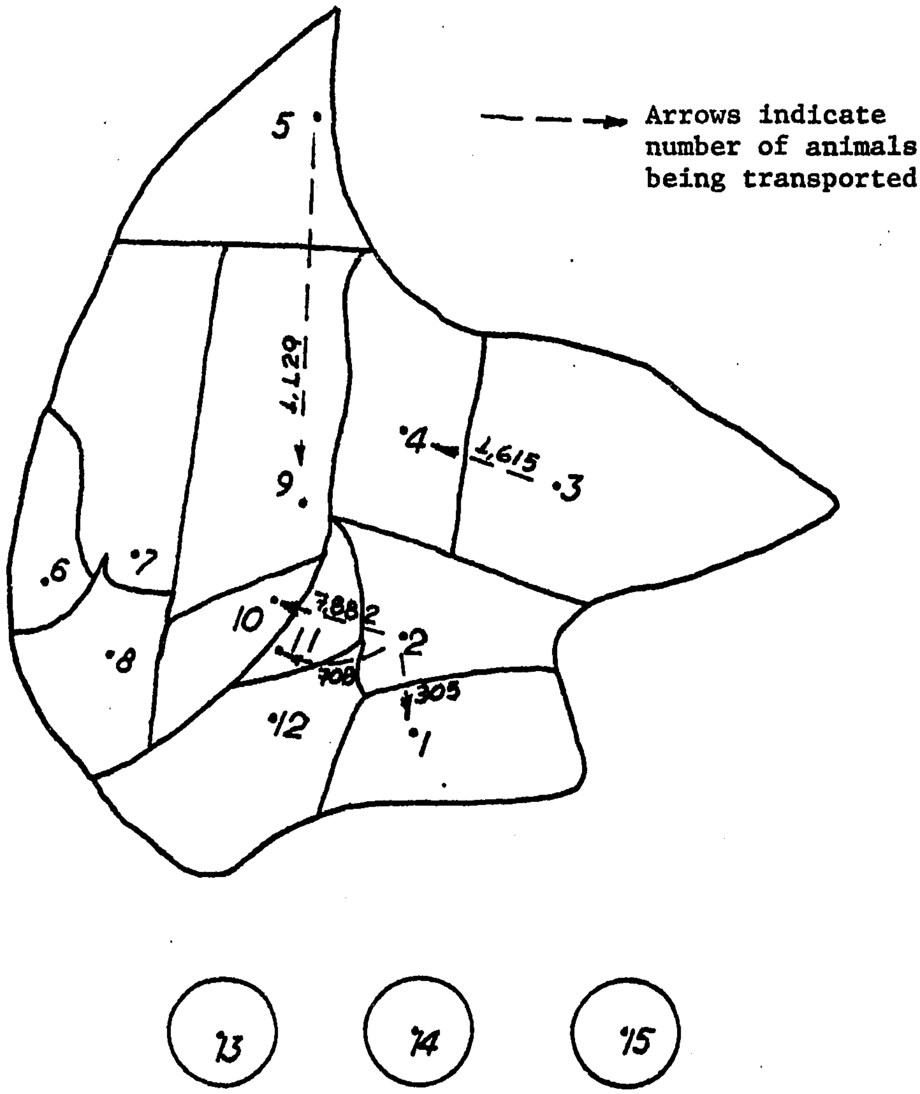

Figure 34. Live cattle flows - scenario D.1

Scenario D.2

After three iterations, a minimum cost solution to the problem was found, which equaled \$b 274,045,076. This solution is \$b 587,713 (.21 percent) lower than that corresponding to scenario D.1. The associated slaughterhouse location pattern is shown in Table 58.

Table 58. Type "H" plants - number, locations, sizes and outputs (scenario D.2)

Region	Slaughter level (Kgs.)	Installed capacity (Kgs.)	Internal rent (\$b/Kg.)
1	10,400,000	10,400,000	+ .76
3	3,120,000	3,120,000	+ .94
4	10,400,000	10,400,000	+1.39
5	1,560,000	1,560,000	+2.05
7	5,200,000	5,200,000	+ .92
9	5,200,000	5,200,000	+ .83
13	5,200,000	5,200,000	+ .59
14	5,056,000	5,200,000	-
15	8,806,000	10,400,000	-
Total	54,942,000	56,680,000	

As the last column of Table 58 indicates, with the exception of region 13, whose internal rent to slaughter operations is increased, and region 14, whose internal rent is reduced to zero, all other regions experience no change in these returns.

The plant location pattern corresponding to Table 58, together with its associated beef flows, are shown in Figure 35. Note that

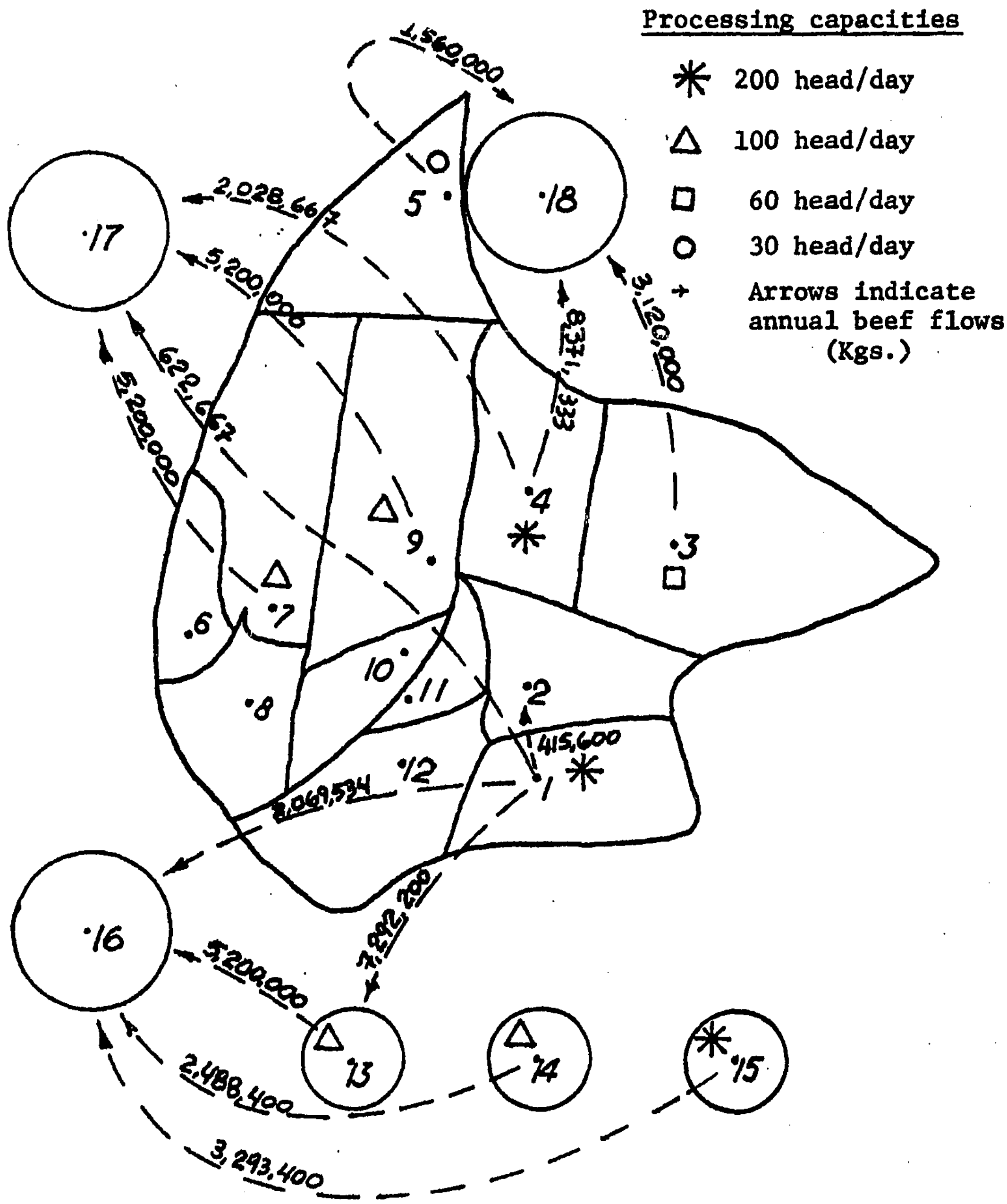

Figure 35. Type "H" slaughterhouse locations and type "H" beef flows - scenario D.2

plant locations and sizes are unchanged in relation to scenario D.1. Type "H" beef flows are, however, affected by the new transportation infrastructure: flows from region 1 to 13 increase significantly, while shipments from region 1 to 16 decrease markedly; exports from region 14 to 16 are decreased, while those from region 15 to 16 increase; and region 13 begins exporting to 16.

Exports from regions 13, 14, and 15 to 16 travel by rail. Those exports from region 15 to 16 are a result of the completed Cochabamba-Santa Cruz rail link.

Type "L" beef flows are shown in Figure 36. Processing levels in low quality beef plants are shown in Table 59.

Table 59. Type "L" plants - processing levels (scenario D.2)

Region	Volume of type "L" beef (Kgs.)	Region	Volume of type "L" beef (Kgs.)
1	1,326,000	9	4,631,400
2	10,608,000	10	3,978,000
3	7,956,000	11	8,160,800
4	1,853,800	12	3,950,000
5	-	13	11,102,000
6	1,580,600	14	5,593,000
7	1,487,600	15	10,676,800
8	3,891,000		

Type "L" beef flows in this case, as compared to scenario D.1 are basically unchanged, although the shipments from region 2 to 15

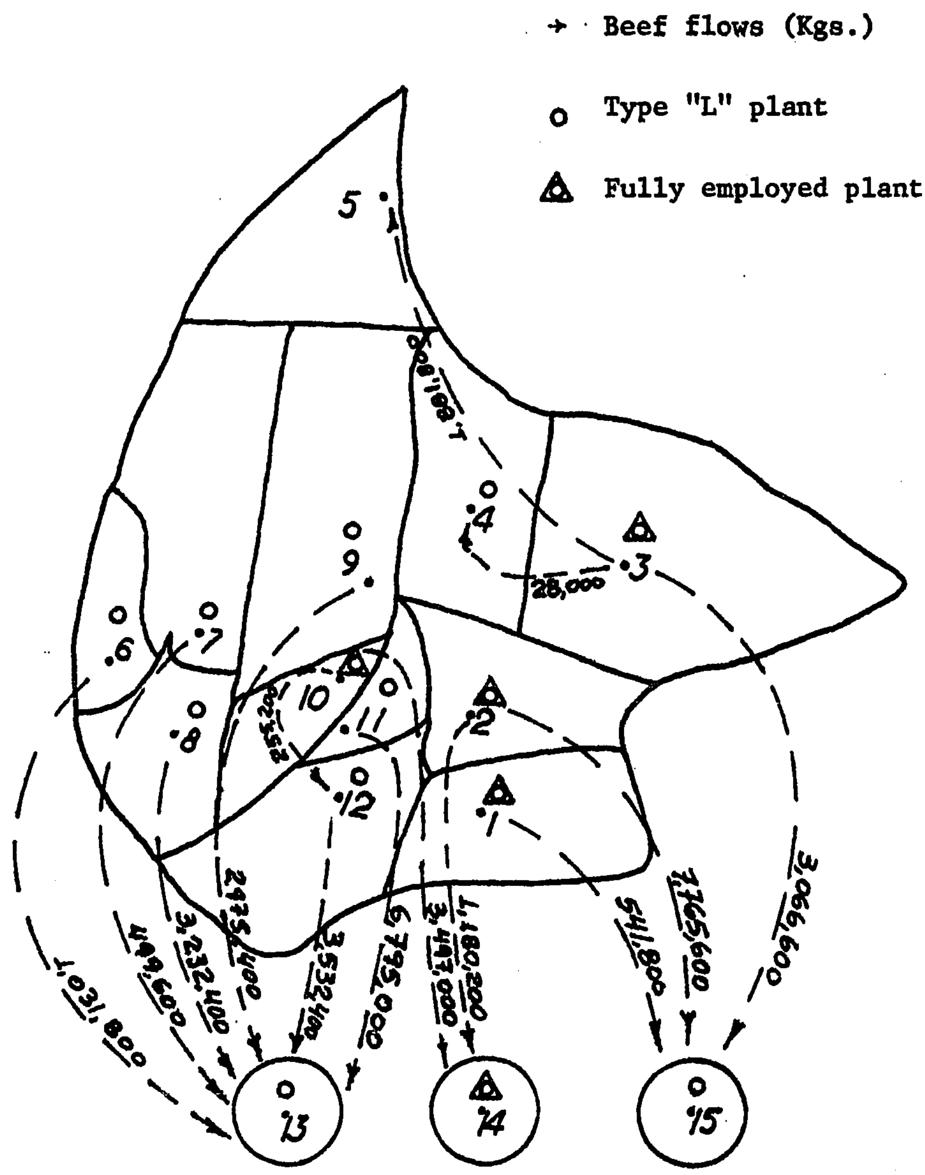

Figure 36. Type "L" beef flows - scenario D.2

increase while those to region 14 decrease.

Live cattle flows for this scenario are the same as in scenario D.1, that is, the new transportation linkages have no impact upon live animal movements.

CHAPTER IX. CONCLUSIONS

Analytical results

The impact of the new transportation projects upon optimal slaughterhouse location patterns and factor-product flows in Beni is relatively minor. Considering one set of transport costs of cattle and beef corresponding to the 1980 transportation infrastructure, and another set corresponding to the expected 1990 infrastructure, it was found that optimal plant sites, sizes, output levels, input sources, and output destinations are relatively unchanged. This was so for various alternative export scenarios of high quality beef.

The effect of the completed transportation infrastructure upon the minimum transport-processing cost solution is relatively minor. Cost reductions brought about by the new linkages range from .17 percent to .35 percent.

The explanation for this occurrence can be found in the relative costs of different modes of transportation. Unless the new road connections can offer tariffs for beef and cattle transportation which are competitive in relation to air transportation, they will have a negligible impact upon optimal plant location patterns in the industry.

Nonrefrigerated air transportation is the only available mode for low quality beef. This was so in 1980 and will still be in 1990.

Concerning the transportation costs for high quality beef (table 37) railroad transportation is cheaper for distances greater than 200 Km., while air transportation is less expensive than truck transportation for distances shorter than 300 Km. In the problem studied, only in one instance (connection 5, 12) did truck transport turn out to be cheaper than air transport; and only in a few cases (connections 15, 13; 15, 14; 15, 16; 13, 16; and 14, 16) was rail transport cheaper than air transport.

Consequently, the complete transportation infrastructure expected to be in existence by 1990 did not bring about any significant changes in the transportation of high quality nor low quality beef.

The analysis presented in Chapter VII (Table 29) shows that, in the case of live cattle, on foot transportation is cheaper than truck and rail. For journeys longer than 80 Km., however, truck and rail transportation are less expensive than the trailing of cattle. Barge transportation is the least expensive of all modes in the longer journeys, and especially so when directed downstream.

A large share of the cattle being transported to slaughterhouses under the 1980 transport infrastructure, travels on foot. One expects that cheaper truck and rail transportation services, brought about by the new linkages, could have a major impact upon animal flows and plant location arrangements in Beni. However, the minimum cost solutions to the various scenarios of high quality beef considered in this study, indicate that, in most cases, it is less expensive to transport carcass beef than live cattle.

One unexpected result of the optimal factor-product flows obtained in this study is the absence of live cattle movements from Beni to La Paz, Cochabamba and Santa Cruz. This is so because it is known that these flows, given the 1980 transportation infrastructure, are significant (see Figure 4).

Such inconsistency between real world conditions and the results of the linear program model can be explained in various forms. Assuming that the beef-cattle industry operates in a relatively cost optimal situation, it is possible that the cattle transport costs used in this study have been overestimated in relation to those of beef. This situation would slant the optimal solutions towards beef rather than live cattle transport.

There may also exist institutional barriers which prevent the industry from attaining cost minimizing patterns of beef-cattle movements. One such institutional barrier could be attributed to the absence of adequate price incentives to current shippers of live cattle to shift to less expensive beef transport modes. Another such institutional barrier may refer to the presence of monopolistic or oligopolistic factors in the industry. These factors may result in much higher beef transport costs for those cattle growers or merchants who are small, and do not have good linkages with slaughterhouse owners, airplane operators, and/or wholesalers at the destinations.

It is also likely that because beef exports are possible in the model, live cattle shipments to regions 13, 14 and 15 from origins in Beni are not convenient. To analyze this alternative, the model could be run with prohibitively high beef transport costs to regions 16, 17, 18, so as to reflect foreign unacceptability of the product.

On foot transportation of cattle may be more appealing than other modes. It is possible that the opportunity cost of the labor involved in transporting cattle on foot is zero. This would be so if the owner of the cattle, his family members, or regular ranch employees did the driving. Moreover, on foot transportation has lower out-of-pocket costs than other modes. This would be an important factor for cattle growers who are short of cash.

Alternative export market scenarios have a much more significant impact upon plant location patterns and factor-product flows, than the modified transportation relationships. Significantly different plant sites, plant sizes, output levels, and factor-product flows are obtained depending on whether Beni exports to Chile, to Peru, to Brazil, or to the three markets simultaneously. The analysis suggests that in order to formulate a slaughterhouse location pattern, foreign demands must be carefully assessed in advance.

Consideration of a few different export scenarios for high quality beef highlights several interesting aspects in relation to slaughterhouse location in Beni and other regions within Bolivia. For example, in all cases: region 15 (Santa Cruz) was assigned a large type "H" beef processing facility of 200 head/day; region 14 (Cochabamba) was assigned a 100 head/day type "H" beef processing facility; region 2 specializes in the production of low quality beef; and the low quality beef processing plants in regions 1 and 2 are fully employed.

Other locations favored as suitable sites for the location of type "H" slaughterhouses, although not in every one of the export scenarios, are those in regions 1, 3, 4, 5, 7, 9, and 13. These locations in regions 8 and 12 are sites of type "H" plants only when all exports of high quality beef are directed to the Chilean market. The locations in regions 2, 6, 10, and 11 are in no case suggested as sites for type "H" plants.

Other sites which in some cases fully employ their existing processing capacities of low quality beef are those in regions 3, 4, 9, 10, and 13. In a few instances, the low quality beef processing capacities of some regions (6, 7, and 8) were left unemployed as those regions specializing in the production of high quality beef.

Matters not considered in the analysis

The analysis that has been undertaken is by no means complete. Many important factors have been left out. Among these we can mention the changes in transport relationships that occur during the dry and rainy seasons of the year. During the rainy season many trails and roads become impassable. At the same time, increased water flows increase the navigability of existing waterways.

Time and budget constraints prevented considering a larger number of future transport linkages and factor-product destinations. Several transport projects, which are likely to be completed in the course of the 1980s have not been incorporated into the analysis. The principal ones among these projects are the roads from Cobija to Apolo, La Paz to Ixiamas, Santa Cruz to San Matias, San Ramon to Puerto Siles, and San Ramon to Magdalena.

Various important existing and potential destinations of beef and cattle from Beni have also been left out of the study. Of these, the main ones are Corumba, Porto Velho, Manaus, and Rio Branco in Brazil; Antofagasta and Santiago in Chile; the department of Pando in Bolivia; and Puno in Peru.

A more complete analysis would also consider other possible plant sites in Beni, such as Riberalta, Puerto Rico, etc. In particular, a potential site at the locality of Puerto Rico (Mamore River) is essential to capture the impact of the Santa Cruz-Mamore River rail connection.

Other types of livestock, such as pigs, sheep, and horses, have also been excluded from the analysis, even though these are likely to share slaughter facilities with cattle. Likewise, the numerous taxes and levies paid by cattle shippers and beef processors have not been considered in the analysis.

Cattle by-products (i.e., hides, tripes, feet, etc.) have not been included in the study. Their consideration would certainly lower the cost of live animal transportation in relation to carcass beef. To compare transport costs of live cattle and carcass beef in a country such as Bolivia, where most by-products are consumed, the costs of transporting these by-products should be added to the costs of transporting beef.

Cattle fattening activities, which are likely to develop by 1990 in intermediate locations (i.e., Alto Beni, Chapare) have been ignored in this study. Their development can be expected to have a major impact upon optimal plant location patterns and factor-product flows in the industry.

The model has not considered the provision of inputs to the beef processing plants, especially water, electric energy, fuel, salt and labor. It has been assumed that all central locations within Beni have adequate amounts of the necessary resources. A complete analysis would have to study these matters thoroughly.

Additional research courses

The analysis has highlighted several areas in which further research can be helpful for plant location studies. These areas refer to factor-product shrinkage rates according to mode, length of journey, type of vehicle/vessel, etc.; operating characteristics of refrigerating equipment in Bolivian roads and rail tracks (i.e., fuel efficiency, speeds, maintenance costs, etc.); time losses in transit and at terminal and transfer points; transportation tariffs of cattle in different modes with distinctions of season, direction of travel, size of load, services in transit, and distance.

The model presented does not permit analysis of direct relative changes in transport costs by mode. One useful extension of the linear programming framework would consist in considering separate activities for beef transportation in different modes (i.e., railroad, truck, and airplane).

The treatment of type "L" plants in this research has not been entirely satisfactory. On the one hand, the assumption of fixed capacities in these plants is not very realistic. Given the relatively low investment requirements, at least in certain locations, it would be more appropriate to relax their capacity constraints. In cases such as the cities of Cochabamba and Santa Cruz, where type "L" plants are already operating at capacity, the possibility of building new plants of this type should be entered into the analysis. On the other hand, the processing costs of these plants should be subject to some adjustments, according to their levels of operation.

The possibility of more than one shift in type "H" plants could also be considered. Given that, in every scenario studied, there are a few plants operating at full capacity, the expanded processing potential, brought about by additional hours of operation, would significantly affect optimal plant numbers and sizes. In the same direction, the possibility of constructing plants with daily processing capacities larger than 200/head should not be overlooked.

The model presented in this study can be used not only to determine an optimal plant location pattern at a certain future date, but also to indicate the optimal order and the specific points in time in which such plants need to be constructed. To obtain these other objectives, it would be necessary to conduct the analysis year by year. For any given year, those plants which have already been constructed are entered as existing capacity. This type of analysis would also permit to consider changes in transport relationships as they occur.

The volumes of type "H" beef to be demanded within Bolivia need to be carefully estimated. Such volumes will be related to the effort made by government agencies and industry groups to educate the consumer; the relative prices of type "H" and "L" beef; and the specific marketing techniques adopted in relation to product presentation, advertisement, promotion, and sale locations.

BIBLIOGRAPHY

Abouchar, Alan. 1977. Transportation Economics and Public Policy. New York: John Wiley and Sons.

Agreement Ministry of Agriculture, Agency for International Development, and Foundation for National Development. 1973. Evaluation Study of the Meat Problem in Peru, Lima, Peru.

Alvarez P., Marcelo; Castro G., Juan Jose; Pizarro de Guardia, Daysi; Hurtado C., Gilberto; and Martines C., Nicolas. 1974. Estudio de Prefactibilidad - Proyecto Ganadero del Gran Chaco Boliviano. Banco Interamericano de Desarrollo, Division de Adiestramiento. Curso de Preparacion y Evaluacion de Proyectos, La Paz, Bolivia.

Banco Agricola de Bolivia. 1970. La Ganaderia Boliviana - Situacion de la Comercializacion de la Carne y Posibilidades para su Desarrollo, La Paz, Bolivia.

Banco Agricola de Bolivia. 1975. Proyecto Repoblamiento Ganadero en Santa Cruz y el Chaco, La Paz, Bolivia.

Baumel, C. Phillip; Drinka, Thomas P.; Lifferth, Dennis R.; and Miller, John J. 1973. An Economic Analysis of Alternative Grain Transportation Systems: A Case Study. United States Department of Transportation, Federal Railroad Administration, Technical Report FRA-OE-73-4.

Beckmann, M. J. and Marschak, T. 1955. "An Activity Analysis Approach to Location Theory." Kyklos 8:125-41.

Black, Eugene R. 1961. The Diplomacy of Economic Development. Cambridge: Harvard University Press.

Brown, Robert T. 1966. Transport and the Economic Integration of South America. Washington, D.C.: The Brookings Institute.

Caceres R., Cristobal; Iriarte S., Luis; Molina V., Vidal; and Vasquez L., Mario. 1974. Estudio de Prefactibilidad - Proyecto de Matadero Frigorifico - Departamento de Cochabamba. Banco Interamericano de Desarrollo, Division de Adiestramiento. Curso de Preparacion y Evaluacion de Proyectos, La Paz, Bolivia.

Case and Company, Inc. - Management Consultants. 1975. The Economics of Alternate Fresh and Frozen Beef Distribution Systems at Supermarkets. Stanford, Connecticut.

Case and Company, Inc. - Management Consultants. 1978. An Updated Look at Beef Distribution Systems, Stanford, Connecticut.

Chern, Wen-Shyong and Polopolus, Leo. 1970. "Discontinuous Plant Cost Function and a Modification of the Stollsteimer Location Model." American Journal of Agricultural Economics 52:581-6.

Cochrane, Thomas T. 1973. El Potencial Agricola del Uso de la Tierra en Bolivia - Un Mapa de Sistemas de Tierra, La Paz, Bolivia: Editorial Don Bosco.

Consejo Nacional de Reforma Agraria (CNRA). 1976. Estudio Socio-economico y Agropecuario - Departamento del Beni, La Paz, Bolivia.

Corporacion de Desarrollo del Beni (CODEBENI). 1980. Diagnostico Agropecuario, Trinidad, Bolivia.

Daniel, Mann, Johnson, Mendenhall; Stanford Research Institute; and Alan M. Voorhees and Associates, Inc. 1968. Bolivia Transport Survey, 8 Vols., La Paz, Bolivia.

De Mesa, Jose and Gisbert, Teresa. 1970. Bolivia: Monumentos Historicos y Arqueologicos. Instituto Panamericano de Geografia e Historia. Mexico, D.F.: Editorial Fournier, S.A.

Dickenson, John P. 1978. Brazil. Boulder, Colorado: Westview Press, Inc.

Duewer, Lawrence A. and Terry L. Crawford. 1977. Alternative Retail Beef Handling Systems. Washington, D.C.: Economic Research Service, U.S. Department of Agriculture.

Eriksen, P. J. 1978. Slaughterhouse and Slaughterslab - Design and Construction. Rome: Food and Agriculture Organization of the United Nations.

Ensminger, M. E. 1976. Beef Cattle Science. Danville, Illinois: The Interstate Printers and Publishers, Inc.

Escobar Q., Hugo. 1976. Informe General Relativo a la Comision Mixta Ferroviaria Argentino-Boliviana. Informe del Ingeniero Delegado Hugo Escobar Q. al Sr. Ministro de Transportes y Comunicaciones Ambrosio Garcia Rivera, La Paz, Bolivia.

Fenn, M. G. 1977. Marketing Livestock and Meat. Rome: Food and Agriculture Organization of the United Nations.

Fifer, J. Valerie. 1972. Bolivia: Land, Location and Politics Since 1825. Cambridge: The University Press.

Food and Agriculture Organization of the United Nations and World Bank. 1978. Draft Report of the Bolivia Meat Industry Project Identification Mission. FAO/World Bank Cooperative Program Report No. 11/78/Bolivia 8.

Food and Agriculture Organization of the United Nations. 1979. FAO Trade Yearbook - 1978. Vol. 32. Rome.

Fowler, Stewart H. 1961. The Marketing of Livestock and Meat. Danville, Illinois: The Interstate Printers and Publishers, Inc.

Fromm, Gary. 1965. "Design of the Transport Sector." In Transport Investment and Economic Development, pp. 89-107. Edited by Gary Fromm. Washington, D.C.: The Brookings Institute.

Furnish, Dale B. 1967. An Analysis of Livestock and Meat Flows in Peru. Iowa Universities Mission to Peru in Cooperation with Agency for International Development and Corporacion Nacional de Abastecimientos del Peru, Lima, Peru.

Galindo Quiroga, Eudoro. 1953. Planificacion Integral del Sistema Ferroviario de Bolivia. Cochabamba, Bolivia: Publicaciones de la Universidad de Cochabamba - Imprenta Universitaria.

Gerrity, Martin V. and Harold D. Johnson. 1956. Motor Truck Transportation of Freshly Killed Beef. U.S.D.A. Marketing Research Report No. 119.

Godfrey, Robert Sturgis, ed. in chief, 1980. Building Construction Cost Data 1981, 39th annual edition. Kingston, Massachusetts: Robert Snow Mearis Co., Inc.

Gollnick, A. F. 1966. A Special Study on Meat Processing and Marketing - Bolivia. United States Agency for International Development, Bolivia.

Gonzales Ruiz, Rene. 1956. La Economia Boliviana y el Comercio Exterior. Oruro, Bolivia: Editorial Universitaria.

Green, William and Swanborough, Gordon. 1978. Commercial Aircraft. New York: Crescent Books.

Greenhut, Melvin L. 1956. Plant Location in Theory and Practice - The Economics of Space. Chapel Hill: The University of North Carolina Press.

Heath, Dwight B., Erasmus, Charles J., and Buechler, Hans C. 1969. Land Reform and Social Revolution in Bolivia. New York: Frederick A. Praeger, Publisher.

Hilger, Donald A., McCarl, Bruce A., and Uhrig, J. William. 1977. "Facilities Location - The Case of Grain Subterminals." American Journal of Agricultural Economics 59:674-82.

Holroyd, William McGinnis. 1972. Number, Size, and Location of Plants for a Honey Marketing-Processing Cooperative. Ph.D. dissertation, University of Maryland.

Hoover, Edgar M. 1963. The Location of Economic Activity. New York: Alfred A. Knopf, Inc.

Howe, James E., et al. 1975. The U.S. and World Development - Agenda for Action 1975. New York: Praeger Publishers.

Hoyle, B. S. 1973. Transport and Development. London: The Macmillan Press Ltd.

Hunting Technical Services Ltd. and Manuel Vivado P. y Asociados - Consultoria Agropecuaria. 1973. Comercializacion y Procesamiento de Carne Bovina y Ovina. Estudio de factibilidad elaborado para el Gobierno de Bolivia.

Hurt, Vernon G. and Tramel, Thomas E. 1965. "Alternative Formulations of the Transshipment Problem." Journal of Farm Economics 47:763-74.

Instituto Geografico Militar. 1980. Mapa de la Republica de Bolivia, Carta Preliminar - 1974, La Paz, Bolivia.

Inter-American Development Bank. 1977. Economic and Social Progress in Latin America. Washington, D.C.

International Food Policy Research Institution. 1978. Projections on Beef and Milk for Latin America. Washington, D.C.

Junta del Acuerdo de Cartagena. April 1978. Bolivia: Produccion, Comercializacion y Procesamiento de Carne Bovina. Documento para Discusion.

Junta del Acuerdo de Cartagena. September 1978. Informe sobre la Mision de Asesoria Administrativa al Programa de Comercializacion de la Federacion de Ganaderos de Santa Cruz.

Junta del Acuerdo de Cartagena. November 1979. Bolivia, Diagnostico de la Situacion Actual de la Red Frigorifica. Sexta Reunion del Consejo Agropecuario, Santa Cruz, Bolivia.

Junta del Acuerdo de Cartagena. October 1979. Diagnostico Subregional - Agroindustria de Carne Bovina. Primera Reunion de Expertos en Agroindustria de Carne y Leche Bovina, Lima, Peru.

King, Francis Richard. 1971. Optimum Location, Number, and Size of New England Apple Packing Plants. Ph.D. dissertation, The University of Connecticut.

King, Gordon A. and Logan, Samuel H. 1964. "Optimal Location, Number and Size of Processing Plants with Raw Product and Final Product Shipments." Journal of Farm Economics 46:94-108.

Klein, Herbert S. 1969. Parties and Political Change in Bolivia: 1880 - 1952. Cambridge: The University Press.

Kraft, Gerald, Meyer, John R. and Valette, Jean Paul. 1971. The Role of Transportation in Regional Economic Development. Lexington: D. C. Heath and Co.

Kriebel, Charles H. 1961. "Warehousing with Transshipment under Seasonal Demand." Journal of Regional Science 3:57-69.

Kurian, George Thomas. 1979. The Book of World Rankings. New York: Facts on Life.

Ladd, George W. 1979. Class Notes. Methods of Agricultural Economics Research (unpublished). Dept. of Econ., I.S.U., Ames, Iowa.

Ladd, George W. and Lifferth, Dennis R. 1970. "An Analysis of Alternative Grain Distribution Systems." American Journal of Agricultural Economics 57:420-30.

Ladd, George W. and Halvorson, M. Patrick. 1969. Least Cost, Number, Size, and Location of Turkey Processing Plants in Minnesota, Iowa, and Wisconsin. Iowa State University Agriculture and Home Economics Experiment Station. Ames, Iowa.

Ladman, Jerry R., Tinnermeir, Ronald L. and Torrico, Isaac. 1977. Agricultural Credit Flows and Use in Bolivia. Report submitted to Rural Development Division - United States Agency for International Development, La Paz, Bolivia.

LeBaron, Allen D. 1977. Income and Household Size Elasticities for Urban and Rural Sectors of Bolivia. Consortium for International Development, Working Paper No. 005/77, La Paz, Bolivia.

Lieb, Robert C. 1978. Transportation - The Domestic System. Reston, Virginia: Prentice Hall Company.

Locklin, D. Philip. 1972. Economics of Transportation. Homewood, Illinois: Richard D. Irwin, Inc.

Lora, J., Carlos; Vidal H., Luis; Olmos R., Serafin; and Mantilla L., Luis. 1969. Informe de la Comision Encargada para el Estudio y la Definicion del Mejor Trazado para la Interconexion Ferroviaria de las Redes Occidental y Oriental del Pais, La Paz, Bolivia.

Mann, I. 1960. Meat Handling in Underdeveloped Countries - Slaughter and Preservation. Food and Agriculture Organization of the United Nations. Rome: FAO.

Miller, Fred. 1973. "Highway Improvement and Agricultural Production - An Argentine Case Study." In Transport and Development, pp. 104-24. Edited by B. S. Hoyle. London: The Macmillan Press, Ltd.

Ministerio de Asuntos Campesinos y Agricultura, Utah State University, y United States Agency for International Development. 1972. Proyecto Ganadero de Bovinos - Carne. Version Preliminar, La Paz, Bolivia.

Ministerio de Asuntos Campesinos y Agricultura, Oficina de Planificacion Sectorial. 1979. Aportes de la Ganaderia, La Paz, Bolivia.

Ministerio de Obras Publicas, Comunicaciones y Transportes. 1968. Plan Decenal de Caminos de Vinculacion Nacional, La Paz, Bolivia.

Ministerio de Planeamiento y Coordinacion de la Presidencia de la Republica, Republica de Bolivia. 1976. Plan de Desarrollo Economico y Social 1976 - 1980, La Paz, Bolivia.

Ministerio de Transportes, Comunicaciones y Aeronautica Civil. 1978. El Transporte Aereo no Regular, La Paz, Bolivia.

Moseley, Malcolm J. 1974. Growth Centers in Spatial Planning. New York: Pergamon Press.

Nelson, Michael. 1973. The Development of Tropical Lands - Policy Issues in Latin America. Baltimore: The Johns Hopkins University Press.

Newmann, A. L. 1977. Beef Cattle. 7th ed. New York: John Wiley & Sons.

Ordeni, A. 1956. "The Transshipment Problem." Management Science 2:277-85.

Organizacion de Estados Americanos y Corporacion de Desarrollo del Beni. 1980. Proyecto Matadero Frigorifico Trinidad. Curso Nacional de Formulacion y Evaluacion de Proyectos Agropecuarios.

Penaloza, Luis. 1953-1954. Historia Economica de Bolivia. 2 Vols. La Paz, Bolivia.

Pinheiro Conduru, Jose Maria. 1974. "Agriculture in the Brazilian Amazon." In Man in the Amazon. Edited by Charles Wagley, Gainesville, Florida: The University Press of Florida.

Pfaffenberger, Roger C. and David A. Walker. 1976. Mathematical Programming for Economics and Business. Ames, Iowa: The ISU Press.

Randolph, Paul H. and Howard D. Meeks. 1978. Applied Linear Optimization. Columbus, Ohio: Grid, Inc.

Rhody, Donald D. 1963. Interregional Competitive Position of the Hog-Pork Industry in Southeast United States. Ph.D. dissertation. Iowa State University. Ames, Iowa.

Rizek, R. L., Judge, G. G., and Havlicek, J. 1965. Spatial Structure of the Livestock Economy - III. Joint Spatial Analysis of Regional Slaughter and the Flows and Pricing of Livestock and Meat. South Dakota State University, Agricultural Experiment Station, Bulletin 522.

Rouse, John E. 1977. The Criollo Spanish Cattle of the Americas. Norman: University of Oklahoma Press.

Sanders, Bernard L. and Fletcher, Lehman B. 1966. Coordinated Egg Production and Marketing in the North Central States - V. Least Cost Egg Marketing Organization Under Alternative Production Patterns. North Central Regional Research Publication No. 171, Research Bulletin 547.

Sarviel, Edward; Fush, Otto; and Moselle, Gary. 1980. National Construction Estimator - 1981. Solana Beach, California: Craftsman Book Company.

Self, H. L. 1967. A Progress Report on Studies of Shrink in Finished Cattle. Iowa State University of Science & Technology Agricultural and Home Economics Experiment Station, Ames, Iowa.

Servicio Nacional de Caminos, Departamento de Planificacion. 1979. Informe - Proyectos Viales en Actual Ejecucion, La Paz, Bolivia.

Shepherd, Geoffrey and Furnish, Dale B. 1967. The Economic and Legal Aspects of Price Controls in Peruvian Agriculture. Iowa Universities Mission in Cooperation with Agency for International Development and Corporacion Nacional de Abastecimientos del Peru, Lima, Peru.

Shepherd, Geoffrey and Furnish, Dale B. 1968. Price Policy for Beef in Peru. Iowa Universities Mission to Peru in Cooperation with Agency for International Development and Corporacion Nacional de Abastecimientos del Peru, Lima, Peru.

Sposito, V. A. 1975. Linear and Nonlinear Programming. Ames: The Iowa State University Press.

St. Clair, James and Richard L. Kelley. 1962. Truck Transportation of Wyoming Livestock. Wyoming Agricultural Experiment Station Bulletin 395.

Stokes, Charles J. 1968. Transportation and Economic Development in Latin America. New York: Frederick A. Praeger Publishers.

Stollsteimer, John F. 1963. "A Working Model for Plant Numbers and Locations." Journal of Farm Economics 45:631-45.

Taafe, E. J., Morrill, R. L., and Gould, P. R. 1973. "Transport Expansion in Underdeveloped Countries: A Comparative Analysis." In Transport and Development, pp. 32-49. Edited by B. S. Hoyle. London: The Macmillan Press Ltd.

Taft, Charles A. 1972. Management of Physical Distribution and Transportation. Homewood, Illinois: Richard D. Irwin, Inc.

Thompson, W. H. April, 1969. Transportation of Livestock and Meats from Iowa. Special Report No. 60. Ames: Agriculture and Home Economics Experiment Station, Iowa State University of Science and Technology.

United Nations. 1979. Statistical Yearbook - 1978. New York.

Vivado P., Manuel. 1966. Beef Cattle in the Eastern Subtropics - Bolivia 1965. Pre-feasibility Study, La Paz, Bolivia.

Vivado P. 1969. Manual del Ganadero. United States Agency for International Development, La Paz, Bolivia.

Valdez, Alberto and Nores, Gustavo. 1978. Growth Potential of the Beef Sector in Latin America - Survey of Issues and Policies. International Food Policy Research Institute, Washington, D.C.

Wagley, Charles. 1974. Man in the Amazon. Gainesville: The University Press of Florida.

Warrack, Allan A. and Fletcher, Lehman B. 1970. "Plant Location Model Suboptimization for Large Problems." American Journal of Agricultural Economics 52:587-90.

Wennergren, E. Boyd and Whittaker, Morris D. 1975. The Status of Bolivian Agriculture. New York: Praeger Publishers.

Wilbur Smith and Associates. 1980. Estudio Integral del Transporte en Bolivia - Segundo Informe Intermedio. Preparado para el Gobierno de la Republica de Bolivia, Ministerio de Transportes, Comunicaciones y Aeronautica Civil, Banco Interamericano de Reconstruccion y Desarrollo y Programa de las Naciones Unidas para el Desarrollo, La Paz, Bolivia.

Wilkie, James W. 1980. Statistical Abstract of Latin America. Vol. 20. University of California, Los Angeles, Latin American Center Publications.

Williams, Willard F. and Stout, Thomas T. 1963. Economics of the Livestock - Meat Industry. New York: Macmillan Company.

Wilson, George W. 1973. "Towards a Theory of Transport and Development." In Transport and Development, pp. 208-230. Edited by B. S. Hoyle. London: The Macmillan Press, Ltd.

Wilson, George W., Barbara R. Bergmann, Leon V. Hirsh, and Martin S. Klein. 1966. The Impact of Highway Investment on Development. Washington, D. C.: The Brookings Institute.

Wycott, T. B. 1962. Cattle Transportation in Washington. Washington Agricultural Experiment Station Bulletin 636.

Zondag, Cornelius H. 1965. The Bolivian Economy: 1952-1965 - The Revolution and its Aftermath. New York: Frederick A. Praeger, Publishers.

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