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A Brief History of Agricultural Research in Bolivia: Potatoes, Maize, Soybeans, and Wheat Compared

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This article contains a discussion of the economic and social determinants of investments in agricultural research in Bolivia. We show that investments on research on export crops (eg. soybeans) has outpaced investments on research in essentially non-traded staples (eg. potatoes). We reassess the model of investments in agricultural research by de Janvry and Dethiers.

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A Brief History of Agricultural Research in Bolivia: Potatoes, Maize, Soybeans, and Wheat Compared

It should be borne in mind that Bolivian agriculture is not of today but of centuries ago. Its modernization will depend largely in the contribution that can be made by effective agricultural research, and by the extension of research results to farmers. Ben Hur Thibodeaux, 1946.

The mechanisms through which demand for technical innovations are articulated tend to exclude peasants and other groups unable to voice their demand at the level of the state. Alain de Janvry and Jean-Jacques Dethiers, 1985.

1. Introduction

Governments in Latin America have canvassed for support by supplying balloters with inexpensive food. Since all people must get food, cheaper food enhances real wages, the more so for the indigent who spend a large share of their income to feed themselves. To lower food prices, governments have intentionally overvalued the exchange rate (and, hence, reduced the price of imported foods), controlled food prices, and subsidized food for low-income groups. Though these policies have won political backing, they have worsened fiscal deficits, lowered smallholder income, and stymied the economies.

Although the goal of getting cheaper food is laudable, the reason why governments want inexpensive food and the means used to get it are, sometimes, warped. For instance, governments may want cheaper food to gain political support, not to modernize the economy. And to lower food prices, governments have carried out injudicious macroeconomic and pricing policies rather than promote agricultural technologies. There is a more prudent way of lowering food prices and stimulating the economy without worsening the fiscal deficit: developing new agricultural technologies through research.

Agricultural innovations have generated economic progress in many developing countries. In fact, the growth of agriculture in a developing nation moves in lock step with the growth of the national economy (World Bank 1982: 44-45 quoted in Timmer 1988). The investments needed to produce agricultural innovations yield large profits. A worldwide survey by Echeverría (1989: 3-13) shows that during the past 30 years, investments in agricultural research in developing countries produced an average return of 54%, more than four times higher than the cut-off return of Development Banks projects (12%); 2.5 times higher than the average return for agricultural projects in the World Bank (18%); and about four times higher than the international cost of capital. 1/

Although investments in agricultural research produces high returns, in developing nations technological innovations in export crops typically march ahead of improvements in non-traded staples because producers of export crops are fewer, mold political opinion, and directly profit from technical change. Exporters often unite to pressure the government to modernize agriculture. In contrast, cultivators of non-traded staples are more numerous, scattered in location, and, so, ineffectual in lobbying. They look at the Green Revolution ambivalently, as they may bear some of the burden of lower food prices (De Janvry and Dethiers 1985).

In this article we review Bolivia's record in developing new agricultural technologies to see whether it follows the conventional path of other developing nations, with their emphasis on export agriculture and their neglect of smallholder staples. In particular, we examine de Janvry and Dethiers's (1985) ideas about the determinants of agricultural research bias in Latin America. They claim that although agricultural research responds to the relative

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1/ Several scholars (e.g. Fox 1985; Hertford and Schmitz 1977; Passour and Johnson 1982) claim that estimates of social rates of return on public agricultural research may have been overstated because they exclude the dead-weight losses produced by the taxes needed to fund the research. Although the critique has merit, it ignores that counterbalancing these dead-weight costs are many general-equilibrium benefits that are rarely taken into account when calculating the social profits of agricultural research. (De Franco and Godoy 1991; de Janvry and Detiers 1985).

price of land, labor, and capital, politics overshadows economics in shaping research. In their model, agricultural research emerges in response to crises and to pressures from producers or from scientists.

The state, acting autonomously, may respond to an agricultural crisis (eg, short-term food shortages, epidemic outbreaks) by funding, coordinating, or facilitating research. The state may also succumb to pressure and pay for research demanded by producer groups. Producers are more likely to lobby for research if they cultivate crops with high own-price elasticity of demand, if they are few, come from a small area, and produce crops which have enjoyed some research in the past. A high elasticity of demand ensures the benefits of research go to producers. A few producers concentrated in a small area makes it easier for them to organize. Research on crops which have enjoyed some research in the past yields quicker (though perhaps not higher) returns than unstudied crops. Another determinant of agricultural research lies within the research establishment; de Janvry and Dethiers claim some lobbying pressure for agricultural research comes from scientists's own research agenda. They conclude that agricultural research in Latin America has concentrated on export crops rather than on non-traded staples, responded to pressure from selected producers, become more private, and lacked a long-run focus because of irregular financing.

After a historical overview of agricultural research in Bolivia, we analyze technological progress in the four most important (legal) crops--potatoes, maize, soybeans and wheat--to see where technical progress has been most marked and why. The commodities include relatively non-tradable foods (potatoes, maize), importable crops (wheat), and exportable crops (soybeans). The goods are produced by smallholder (potatoes, maize) and by medium-sized firms (soybeans, winter wheat). These commodities weigh heavily in the household purse, absorb much land and labor, produce foreign exchange, and account for a large share of the agricultural Gross Domestic Product.

2. Historical overview of agricultural research in Bolivia

2.1 Before the second world war: neglect

Like many Latin American countries, Bolivia ignored the development of agricultural technology until the second world war (Mosher 1957: 253). Before the war the Ministry of Agriculture lacked interest in funding agricultural research. Agricultural researchers restricted themselves to studies on irrigation, and agricultural extension agents restricted themselves to renting out farm equipment (Thibodeaux 1946: 53). Bolivia did not have a group lobbying for farming research. An agricultural school founded in Santa Cruz in 1939 closed after three years because of financial problems and small enrollment (Ibid.: 51).

Before the war landed estates tied up much of Bolivia's labor and land and hindered the modernization of agriculture by discouraging rural education or the adoption of new technologies by servants. Bolivian landowners, like their counterparts in Mexico, curbed the education of rural people for fear of losing them to urban employers (Leonard 1952: 167-168; Kelley and Klein 1981:76; Kowalewski and Saindon 1992). Independent smallholders residing outside the dominion of landed estates had two to three times more education than peons living in haciendas (Ibid.:74,79). Landowners neglected to modernize agricultural because, in part, local and central governments levied taxes on production rather than on land and landowners had access to cheap labor (Thibodeaux 1946: 85, 214). Some government policies, such as overvalued exchange rates, discriminated against agriculture and lowered incentives to innovate (De Franco and Godoy 1991: chapter six). Only one grower's association, the coca producers of the Yungas, acted as a lobbying group, but chiefly to force the government to reduce taxes, not to increase research.

2.2 The second world war and the Bohan Mission

The war changed things. During the war the United States courted Bolivia, with money and technical assistance to enlist Bolivia's cooperation in meeting the abnormal demand created by the war for strategic metals and for crops, such as quinine, rubber, and edible oils (Wennergren and Whitaker 1975: 204). The reduction in the number of cargo vessels in the New World during the war also made the United States see bilateral aid as a way of increasing Latin America's food supply and reducing its food imports from the United States (National Planning Association 1956: 41).

To formulate its aid plan for Bolivia, the Department of State selected in 1941 a task force headed by Merwin L. Bohan, a veteran foreign service officer. 1/ The Bohan Mission found that help to Bolivia need to center in developing a modern road from Santa Cruz to Cochabamba, improving mineral production, and transforming Bolivia's indigenous agriculture (Heilman 1982: 53-56). To achieve these goals, Bolivia, the Mission argued, would need a steady infusion of outside technical assistance and economic support. The Bohan report served to justify a $26 million loan from the Export-Import Bank of the United States to pay for programs in economic aid and technical cooperation to Bolivia.

The Mission's blueprint for transforming Bolivia's traditional agriculture was far-sighted, acute, and sober, reading with equal relevance today as it did half a century ago. The report remained "basic reading for every embassy economic counselor and USAID mission director" until the late 1960's (Heilman 1982: 59-60). Bolivia's planners used (though they did not carry out) the findings of the Bohan report for nearly two consecutive decades; the United Nations's Keenleyside Mission to Bolivia in the early 1950s also used parts of the Bohan report (Thorn 1971: 165-166). Aware that mining had not given bolivians a "high standard of living" and that Bolivia could no longer depend of mining for its sustenance because the ore reserves would in time disappear and because reliance on tin exposed Bolivia to a hysterical metals market, the Bohan Mission said agriculture had to be brought to the center stage of Bolivia's development discourse (Thibodeaux 1946: 14). And to enliven agriculture policy-makers would have to invest first and foremost in agricultural research and extension. Inspired by the prominent role agricultural research had played in the development of the United States economy, the Bohan Mission was unreserved about stressing the need to do good agricultural research to stimulate Bolivia's economy. 1/

The Bohan Mission envisioned a decentralized and interlocked agricultural research network, modeled after the land grant colleges and universities of the United States (Ibid.: 47). The main agricultural research station would be lodged in Cochabamba to draw on the expertise of the only University in Bolivia offering instruction in agriculture, San Simón. Sub-stations would be scattered in Bolivia's principal ecologies: Lake Titicaca, the Central highlands, the Yungas, Sucre, Villa Montes, Santa Cruz, the Amazon, and Beni. Scientists at sub-stations would study different commodities: tubers and pasture in Lake Titicaca; livestock, pasture, and irrigation in the central highlands; fruits, coffee, and quinine in the Yungas; fruits and food crops in Sucre and Villa Montes; livestock and pasture in Santa Cruz; cattle and rubber in the Beni and the Amazon (Ibid.: 48-49). The Bohan Mission also recommended to recruit professionals through competitive entrance exams, offer adequate salaries, set up a merit system of promotion, and

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2/ The Bohan Mission worked in Bolivia from December 1941 until June 1942, submitting a final report to the secretary of state shortly after its return from South America. B. H. Thibodeaux and W. V. Harland of the United States Department of Agriculture wrote the section on agriculture. Thibodeaux later summarized his findings for a doctoral dissertation at Harvard (Thibodeaux 1946). The complete Bohan report has not been published. The first part of the report appeared in Spanish in 1988. Since the first part is Thibodeaux's dissertation (Thibodeaux 1946), we have chosen to rely on Thibodeaux's original work rather than on the translation.

3/ In a paragraph that reads with prophetic relevance today, the mission noted: "antiquated production practices that originated hundreds of years ago are still followed by most farmers because they are not familiar with improved methods or with the advantages of using them. Relative to the need very little agricultural work of a scientific nature has been done in Bolivia... With the exception of localized work undertaken in connection with recent studies of irrigation possibilities, no systematic soil survey has been made in the country... Even climatic data is paltry and most is collected by private individuals... The fields of breeding, pathology, entomology and others related to agricultural production have hardly been touched"... (Ibid.: 45).

grant job security to agricultural scientists and extension agents to reduce the turnover of scientists and extension agents and to build a lasting research institution.

Besides setting up an institution for agricultural research and extension, the Bohan Mission identified other topics which also needed attention: increasing the production of important staples (eg, rice, sugar, wheat) which Bolivia imported; improving agricultural marketing and credit; investing in transport and irrigation; and revamping rural education (Ibid.: 221-222). Cognizant development would take a long time and sustained effort, the Bohan Mission logically enough envisioned the transformation for Bolivia's indigenous agriculture happening slowly over the next decades, needing long-term planning and stable assistance form the United States. To help pay for development and avoid burdening mine owners with more taxes, the Mission argued, the government would need to raise additional revenues by modernizing its tax administration (Heilman 1982: 56-58).

Despite the findings of the Bohan Mission, progress in setting up a research system during the war years was slow. True, Bolivia set aside land for agricultural experimentation and expanded rural banking during the mid 1940's but the nationalistic government of President Villarroel (1943-1946) slowed progress by being ambivalent about the merits of foreign assistance. With the advent of more liberal governments after Villarroel's fall, the Ministry of Agriculture expanded its programs of agricultural research, extension, and credit (Wennergren and Whitaker 1975: 205). In 1947 crop and pasture research and seed production started at the experimental station of Tamborada, Cochabamba. A year later the government set up similar programs in the experimental stations of Belén, in the highlands, and in Saavedra (Heilman 1982: 66). Official endorsement from the United States for the type of technical cooperation urged by the Bohan Mission came in 1949 with President Truman's Point IV Program designed to "make available to peace-loving peoples the benefit of our store of technical knowledge ... to help them realize their aspirations for a better life" (National Planning Association 1956: 40).

2.3 The Inter-american Agricultural Service

Despite the Bohan's Mission plea to modernize Bolivia's agriculture, and the progressive changes of the late 1940s, agricultural research remained undeveloped until the early 1950s. For reasons which are still unclear, the United States disbursed money slowly for agricultural research during the late 1940s and early 1950s (Wilkie 1982: 600-601). Impetus to change agricultural technology only came after the 1952 Revolution and the land reform of 1953. During the early 1950s the United States again tried to woo Bolivia with foreign aid and technical cooperation to prevent it from drifting into undesirable political paths, such as communism, or from reverting to the political landscape of pre-revolutionary days, with its landed oligarchy and tin barons. The uncontrolled land invasions after the 1952 Revolution depressed domestic food production and created urban food shortages. The Eisenhower administration viewed urban deficits with alarm because they could crack the brittle political stability of Bolivia. It therefore promptly increased food aid and technical cooperation to meet Bolivia's food needs (Wilkie 1982: 601). Internally, the Bolivian government needed to win the political support of the newly enfranchised smallholders and, so , approved programs of agricultural research and extension.

The unusual combination of good will and aid from the United States and the need to please its rural constituency, made the Bolivian government in 1952 join with the United States in setting up the Inter-american Agricultural Service (IAS). The IAS was designed to cooperate in research and extension to improve the production of staples, pastures, and livestock. Headquartered in the city of La Paz, but with agricultural research stations dispersed in the countryside, IAS was directed by American administrators and financed by the United States. 1/ As a semi-autonomous institution servicing the Ministry of Agriculture, IAS was free from domestic tussles and bureaucratic bottlenecks. The autonomy of IAS allowed "creative administrative innovation" among American and Bolivian personnel and a sharing of "administrative responsibilities in an environment largely insulated from normal

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4/ The initial idea was for the Bolivian government to pay for a larger share of IAS' budget over time until Bolivians could take over the financing and administration of IAS.Some observers likened the IAS to "a flatcar onto which a project could be loaded and carried to the point at which it [could] be transferred entirely to a wholly domestic agency of the host government. This flatcar [could] carry a number of projects simultaneously, unloading each at its appropriate destination, and taking on new projects" (National Planning Association 1956: 31).

bureaucratic processes" (Zuvekas 1977: 54). Managers established their own procedures, including the hiring and the firing of staff (National Planning Association 1956: 7).

As was true with other agricultural programs of the United States in Latin America in the 1940s and early 1950s, at IAS research initially overshadowed extension (Rice 1974: 55-69, 404; National Planning Association 1956: 51). But by the mid 1950s emphasis at IAS started to switch from research to extension, in response to a similar shift in priorities in the USDA (Rice 1974: 63-67; Judd, Boyce, and Evenson 1986: 78; National Planning Association 1956: 50-51). The change reflected in part the jockeying for power between extension agents and researchers in the USDA and eventual victory of the extension agents. In Bolivia, emphasis was placed on importing technologies from the United States and releasing them after quick tests for adaptation to local ecologies. Agricultural research in Bolivia and Latin America was seen as a "converter" operation capable of importing technologies and adapting them to the country. Insufficient emphasis was placed in building a country's internal capacity to generate its own agricultural expertise (Trigo, Piñeiro, and Sábato 1983: 132-135)

IAS built a strong extension program during the 1950s, sending agents to Chile for training (Heilman 1982: 67-68; Alexander 1958: 262). By the mid 1950s, Bolivia stood out among Latin American nations for excelling in the quality of agricultural extension, particularly in the lowlands (Mosher 1957: 396). In a harsh review of agricultural extension in Latin America, Rice (1974: 359-360) concluded that extension had not worked well in most Latin American nations, except in the Bolivian lowlands, the only area "where persons outside the official extension service were willing to support the extension service's claim for recognition" (Ibid.: 359). Extension agents ministered to the needs of farmers in 60 out of the 97 provinces and seven out of the nine departments of Bolivia (Heiman 1982: 69; National Planning Association 1956: 51).

As the Bohan Mission had envisioned, agricultural research grew out of four experimental stations and six substations scattered in the countryside. (Alexander 1958: 262). Much of this early work culminated in the release of improved varieties of potatoes, maize, and rice, better sheep husbandry techniques, development of vaccines against hoof-and-mouth disease, and the successful introduction of Zebu cattle, which turned Bolivia into a net exporter of beef (Wennergren and Whitaker 1977; Zuvekas 1977: 55-56; Alexander 1958: 179). Within a few years, 90% of all rice grown in Bolivia came from improved, certified seeds, allowing Bolivia to attain rice self-sufficiency (Heilman 1982: 74-75). Many of the new technologies developed or adapted by IAS soon captured the attention of smallholders. 1/

The high quality of agricultural research and extension received unmistakable praise from Mosher (1957) and the contentious Eder, a harsh critic of policy making and foreign aid in Bolivia during the mid 1950s. 1/ But the achievements of IAS soon withered. In the late 1950s and the early 1960s programs to develop and disseminate agricultural technology slackened as the Bolivian government withdrew support and the United States, "in a continent-wide move of ending IAS-type services" (Rice 1974: 73), took out technical assistance and foreign aid from Bolivia. As Point IV phased down, the United States handed over financial and administrative responsibilities for agricultural research and extension to the Bolivian government.

As IAS ended in the early 1960s, the Alliance for Progress and the United States Agency for International Development (USAID) tried to replace it. The United States transferred the research and extension facilities of IAS to the Ministry of Agriculture, though it continued to finance agricultural research and extension (Rice 1974: 67; PAU

5/ During the 1950s Alexander wrote: "people engaged in [IAS] demonstration programs have declared the Indians were by 1957 beginning to use them. Although it is too early to see the results in increased production, the Indians are swarming in to the experiment stations to see and learn new methods of planting and cultivation". (1958: 262)

6/ While serving in Bolivia, Eder wrote: "the men employed by [IAS] in general, were for the most part dedicated men and experts in their respective fields--not book experts but men capable of shearing a sheep (or llama), building a hen house, or engaging in laboratory research on hoof-and-mouth disease. The high standards then maintained by the agricultural and highway services in Bolivia are a tribute to the then Chief of the U.S. Operations Mission...results observed in other countries in Latin America leave much to be desired". (Eder 1968: 81-82)

1963: 45). After IAS ended, physical infrastructure deteriorated, salaries for researchers dropped, and scientists left IAS for better paid jobs abroad or in private firms (PAU 1963: 46; Zuvekas 1977: 55, 57).

Public funding for agriculture plummeted after the mid 1960s. Whereas in the mid 1960's Bolivia had put 38% of agricultural expenditures to raise agricultural productivity--credit, land titling, research, extension, planned colonization--by 1973 the government had cut expenditures in these areas to 4% of its agricultural budget (Wennergren and Whitaker 1975: 211). United States aid to agriculture dropped with the Alliance for Progress. From 1942 until 1961, 8.5% of United States aid to Bolivia went to agriculture; by 1962-66, the share has fallen to 3% (Wilkie 1969: 10). As Wilkie shows, beginning in the 1960s United States aid to Bolivia went to budgetary support of the central government, rehabilitation of moribund public mining firms, and loans for the development of commercial agriculture in the eastern lowlands instead of rural education, rural health, and traditional agriculture (Ibid.).

In 1961 USAID started to finance American land grant universities (principally Utah State University) and the USDA to work in special projects. Unlike the past, USAID avoided large technical assistance, budget support, and the building of Bolivia's own agricultural research capabilities (Rice 1974: 67-68). The disappearance of IAS and the expansion of USAID during the 1960s and 1970s coincided with a time when the Bolivian government's gaze and efforts in agriculture turned toward financing private, commercial farmers in the eastern lowlands rather than toward supporting agricultural research. During the 1970s the government extended indiscriminate credit to commercial producers of sugar, cotton, and rice, who never repaid (Eckstein 1983).

2.4 The status of Bolivia's agricultural research at the end of the 1980s

Bolivia's present achievements in agricultural research pale against the past and against other Latin American nations. At present Bolivia spends the least on agricultural research among Latin American countries. Table 1 shows that Bolivia's expenditures on agricultural research amount to only 0.1% of its agricultural GDP, though a recent study suggests the estimate may be higher, reaching perhaps 0.2% of agricultural GDP (World Bank 1990: 7). At present, the central government spends less than two million dollars on agricultural research--one million for IBTA (Instituto Boliviano de Tecnología Agropecuaria) in the highlands and the balance for CIAT (Centro de Investigación de Agricultura Tropical) in the lowlands (World Bank 1990: 6). 1/

Bolivia's investments in agricultural research as a percentage of agricultural GDP (0.096% to 0.2%) are below the annual expenditure goals (recurrent plus capital) for agricultural research in developing countries set by the United Nations (0.5% of agricultural GDP) or by the World Bank (1% to 2% of agricultural GDP) (Pardey, Kang, and Elliott 1989: 262-263). In neighboring countries, such as Paraguay, Argentina, or Brazil, expenditures on agricultural research as a percentage of agricultural GDP are two to eight times higher than in Bolivia.

At present, Bolivia's principal public research institutions cover different geographical areas and commodities: IBTA on smallholder crops in the highlands and valleys; the Centro de Investigaciones Fitogenéticas de Pairumani (CIFP) on maize in Cochabamba; and CIAT on commercial crops and livestock in the lowlands. In addition, many non-government organizations draw on a total budget of about ten million dollars per year to support extension services. These organizations behave autarkically, devoid of links to national research organizations.

7/ Unless we say otherwise, all references in this article are to Bolivia's (not Colombia's) CIAT.

Table 1. Expenditures on agricultural research in selected countries in Latin America and the Caribbean as percentage of agricultural GDP

Country	Year [a]	Research Expenditures as % of Agricultural GDP
Brazil	1981	0.847
Venezuela	1983	0.843
Paraguay	1983	0.636
Mexico	1982	0.442
Colombia	1986	0.437
Uruguay	1986	0.381
Ecuador	1986	0.317
Dominican Republic	1983	0.241
Argentina	1985	0.219
Costa Rica	1984	0.137
Bolivia	**1983**	**0.096**

[a] Year for which latest information is available
Sources: Pardey and Roseboom (1990), and World Bank (1990a)

At the core of Bolivia's agricultural research institutions lies IBTA. Owing to low salaries, irregular financing, and small research budget, professionals enter and exit continuously, with an average yearly turnover during 1986 to 1989 of 22% to 30%. 1/ IBTA undertakes research on virtually all highland crops, but only seems to make advances on commodities, such as oats or quinua, which receive bilateral aid. Having few new agricultural technologies for dissemination and paltry funds for extension, IBTA has been impotent to create a Green Revolution (De Franco and Godoy 1991). The Inter-american Development Bank funded $8 million to IBTA during the late 1970s and early 1980s, with not very significant results. The World Bank recently financed $20 million to improve IBTA's operations but it is too early to evaluate the results of the project.

Over the past decade Bolivia's most important advances in agricultural research and extension have come from CIAT, the mouthpiece of the well-organized, commercial lowlands producers of soybeans and winter wheat. These producers have on their own financed and executed good agricultural research, as we shall see below.

3. The study: research on potatoes, maize, soybeans and wheat

Field work took place between July and August 1990; in the valley of Cochabamba to study the new and the old potato, maize, and wheat technologies; in Santa Cruz to study traditional and improved soybean and wheat technologies. Farmers and businessmen were interviewed to estimate the costs of production, yield trends, and labor needs of different technologies. Scientists and extension officers at Bolivia's main agricultural research centers were also interviewed to get historical information on the technologies available.

To compare the progress in agricultural technology between relatively non-tradable smallholder staples and tradable crops, we selected potatoes, maize, soybeans and wheat for closer scrutiny. These crops generate much foreign exchange, employment, calories, and account for a large share of household expenditures. Table 2 highlights

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8/ IBTA had at the end of the 1980s, about 250 professionals, 17 with an MS degree and only 2 holding a PhD degree. To raise their salary, scientists and extension agents sell the produce of experimental stations, or take side jobs in non-government organizations. In this situation the rational official who has good skills, and no private income, looks for aid projects in which he can work and also feels that his interests are best served by following the directives of the aid agency rather than the official ministry policies. The result is close to anarchy on the planning, evaluation and implementation of projects, causing major distortions in the use of limited research funds (World Bank 1990: 7).

the economic significance of the commodities under study, and Table 3 shows the trends of production, area and yield.

These crops account for over 6% of the gross value of total production in the country. Maize and potatoes account for 38% of Bolivia's agricultural GDP. Soybeans account for 21% of the value of agricultural exports. Maize, potatoes, and, to a lesser extent wheat, employ many people. Maize alone absorbs the equivalent of 85,000 full-time laborers per year, or 12% of the rural population. Maize and potatoes account for a third of the total cultivated area in the country; with wheat and soybeans, the area under these crops reaches almost half of the total arable land under production. Maize, potatoes, and wheat account for 43% of the total calories and for 70% of the vegetable proteins consumed by an average Bolivian. Ten percent of the total expenditures for an average Bolivian household go to maize and potatoes. The 1987 Social Accounting Matrix for agriculture shows that farmers and wage earners spend 13% of their total household expenditures on maize and 5% on potatoes (De Franco and Godoy 1991: Appendix 2).

Table 2. Estimated socio-economic importance of four selected crops in Bolivia

Percentage of	Estimate	Potatoes	Maize	Soybeans	Wheat
Agricultural GDB[a]	1988	21.6	16.3	2.1	1.3
Agricultural exports[b]	1987	0.0	n.s	21.0	0.0
Total cultivated area[c]	1988	10.6	22.0	5.5	6.0
Calories/day[d]	1980	7.6	12.8	n.s	22.2
Vegetable proteins/day[d]	1980	15.4	18.1	n.s	36.8
Total household expenditures[3]	1987	7.4	2.5	n.s	n.a
Rural employment[f]	1990	8.3	11.6	n.s	0.7
Gross value of production[e]	1987	4.22	1.66	0.22	0.16
Total population involved in production[g]	1989	160.0	86.0	4.7	6.0

[a] MACA (1990, 1990a). We assume the gross value of production represents 80% of GDP.
[b] World Bank (1990: 78)
[c] MACA (1990a)
[d] FIDA (1985 vol 2, p. 33).
[e] De Franco and Godoy (1991: Appendix 2). Percentage
[f] Full-time person equivalents per year of producers divided by full-time farmers (733, 131). Authors's estimates.
[g] De Franco and Godoy (1991: Chapter Five). 1000's.
n.s = not significant; n.a. = not available

3.1 Potato research

At the core of Bolivian agriculture lies the potato. Farmers plant potatoes rather than other crops in fallow common-fields which have just been open to use to take advantage of the fertility of rested soils (Orlove and Godoy 1986). Potatoes occupy the greatest land area in the highlands (25% to 45%) and the second largest area after maize in the valleys (Urioste 1975: 39-40; Villaroel 1988; Fernández Calderón 1896: 117).

Potato cultivation and processing employs many people. In 1987 about 65% of rural households grew potatoes, but the figure for the highland of the Departments of La Paz, Oruro, and Potosí reached 75% (FIDA 1985, Vol 1: 151). Potato cultivation at present employs the equivalent of about 66,000 workers. Potatoes account for 25% to 50% of the labor employed in all highland agriculture (Fernández Calderón 1986: 130). Village studies show that over half of the income of highland farmers comes from potatoes even though farmers only sell 13% of potato production (Maletta 1989; Urioste 1975: 38. The

Table 3. Production, Area, and Yields of Potatoes, Maize, Soybeans and Wheat in Bolivia, 1980-1989

Year	Potatoes			Maize			Soybeans			Wheat		
	Production[a]	Area[b]	Yield[c]	Production[a]	Area[b]	Yield[c]	Production[a]	Area[b]	Yield[c]	Production[a]	Area[b]	Yield[c]
1980	786	168	4.6	383	293	1.3	47	37	1.2	60	100	0.6
1981	866	177	4.8	503	313	1.6	57	34	1.6	66	96	0.6
1982	900	159	5.6	449	285	1.5	86	48	1.7	66	96	0.6
1983	316	108	2.9	337	260	1.2	64	42	1.5	45	75	0.6
1984	675	155	4.3	496	321	1.5	69	42	1.6	78	98	0.7
1985	678	163	4.7	553	348	1.5	106	67	1.5	74	100	0.7
1986	703	144	4.8	457	294	1.5	149	72	2.0	81	106	0.7
1987	814	142	5.7	480	302	1.5	121	60	2.0	76	94	0.8
1988	825	143	5.7	445	293	1.5	151	75	2.0	62	81	0.7
1989	621	127	4.8	375	278	1.3	259	128	2.0	60	85	0.7

[a] Area = 1,000 ha [c] Production = 1,000 mt [b] Yields = mt/ha Source: Ministry of Agriculture

1987 agricultural Social Accounting Matrix of Bolivia shows that a quarter of the income of all farmers comes from potatoes (De Franco and Godoy 1991, Appendix 2). Potatoes absorb 90% of commercial fertilizers in Bolivia (CID 1982: 70). On the consumption side, potatoes account for about 40% to 50% of the calories consumed by rural highland households (MOP 1985; Wennergren and Whitaker 1975: 53-56). Potatoes account for about 8% of the calories consumed by an average Bolivian. In the highlands, potatoes have a higher caloric yield per hectare than most other crops. Some types of processed potatoes (*chuñu, t'unta*) are eaten mainly by the urban and by the rural poor. During 1978-86, potatoes accounted for a quarter of total agricultural consumption in an average Bolivian household. During this period expenditures on potatoes as a share of total household expenditures averaged 3% to 13%, depending on the social class.

Despite the importance of potatoes in the Bolivian economy, potato yields have declined steadily for more than two consecutive decades. Yields per hectare in Bolivia are among the lowest in Latin America. Potato yields in developing and developed countries grew by 1.8% and 0.8% per year during 1961-85. Virtually all Andean countries experienced positive growth rates in potato yields of about 0.8% per year during this period. In contrast, Bolivia saw a decline in potato yields of -0.6% per year. During 1961-74, an average farmer in Bolivia harvested 5.8 mt of potatoes per hectare each year; by 1975-88, average annual yields had declined to 5 mt/ha (Horton D. 1988: Tables 7-9; FAO 1988: 55). 1/

The golden age of potato research in Bolivia dates back to the 1950s and early 1960s. At that time IAS, in cooperation with the Ministry of Agriculture, developed experimental stations for potatoes in the valleys of Cochabamba (La Tamborada, Toralapa) and in the highlands of la Paz (Belén). Researchers identified four high-yielding potato varieties: *Sani Imilla, Imilla, Blanca, Runa*, and 54-510-61. The new varieties spread fast among smallholders because they increased yields and producer incomes at a reasonable cost. Already by 1974, 75% of the smallholders in the Department of La Paz used improved potato seeds (Urioste 1989: 113). Nationally as many as 30% of producers may have used improved varieties by the mid 1970s (Zuvekas 1977: 28). Research on potato technology ended abruptly in the early 1960s when IAS left Bolivia. Efforts since the mid 1960s have focused on importing clean genetic material (often native varieties from Bolivia) from the International Potato Center (CIP) in Lima and multiplying it for local users.

During the 1980s Bolivia started to certify potato seeds. IBTA imports clean genetic material and produces pre-basic seeds in its experimental stations. IBTA offers basic sees to non-government organizations and to private and public companies for the commercial production of certified seeds. Poor seeds find their way to an informal system of seed distribution. The program has worked well and has reduced the costs of producing seeds at least in Cochabamba (Bustamante 1989: 24). Although the production of certified seed has increased (UPS/SEPA 1989: Annex 22), it is still small (CNS 1988). In 1989 IBTA, financed by the Swiss Development Corporation with $2.5 million and helped with technical assistance from CIP, started a two-year project, PROINPA 1/, to improve the quality of research and production of potato seeds (World Bank 1990: 8). This project will select new varieties resistant to *Phytophthora infestans* and *Synchytrium envobioticum* (PROINPA 1989; Torrico 1990). Another project, PROSEMPA 1/, will distribute certified seeds. It is too early to evaluate the effect of either project.

The experience of CIP in Peru shows where the new potato technology may spread and how it may affect producers in Bolivia. In the andes high-altitude communities of smaller farms produce potatoes at a higher cost than lower-lying areas because of smaller climatic risks, greater possibilities or irrigation, and a

9/ The causes for the decline in potato yields in Bolivia are unclear (UPS/SEPA 1989: 19). Before the 1952 Revolution, local taxes on potatoes reduced the incentives to improve technology (Thibodeaux 1946: 202). Afterwards, explicit government price ceilings on some staples coupled with rising costs of chemicals and overvalued exchange rates reduced the profits of cultivating potatoes, making farmers reluctant to adopt new varieties (Urioste 1989: 114; Wennergren and Whitaker 1975: 95; Zuvekas 1977: 69).

10/ Proyecto de Fortalecimiento de la Investigación y Producción Prebásica de Papa.

11/ Proyecto de Fortalecimiento de Multiplicación y Distribución de Semilla de Papa.

gentler topography, which allows the use of oxen, tractors, land consolidation, and economies of scale. In Peru new potato varieties have spread more on the coast than on the highlands. The highlands, though, remain the seed basket of the nation because highland potatoes are less susceptible to attacks from pests and diseases. Preliminary information in bolivia also shows that foreign, high-yielding potato varieties (eg, Alpha, Radosa, Desireé, Diamond) do best at lower elevations (UPS/SEPA 1989: 9). Even some improved varieties traditionally grown in the highlands (eg, Huaicha Paceña) are now grown in Santa Cruz as a winter crop. As the new potato technology spreads, the highlands of the Departments of Oruro, Potosí, and La Paz will become potato seed producing centers for the rest of the nation. The focus of the commercial potato production will probably shift to lower areas (CNS 1988: 13, 20; UPS/SEPA 1989: 6,9).

3.2 Maize research

Farmers produce maize in Bolivia in two regions, for two chief uses. In the lowlands--principally in the chaco and in Santa Cruz--people plant maize for cattle feed. In the valleys, 1,500 meters above sea level, smallholders grow maize to brew chicha (an alcoholic beverage), to toast, to use in soups, or to eat on the cob.

Along with soybeans, maize is one of the few agricultural commodities which has enjoyed an increase in yields over the past two decades. Maize yields during the 1970s reached 1.3 tons per hectare; by the 1980s, yields had increased to 1.5 mt/ha despite the droughts of 1983 and 1989 (Table 3; Avila 1988: 4). Since 1973, maize yields have grown by 1.8% per year, slightly ahead of the average for Colombia, Ecuador, Peru, and Venezuela (1.6%), but below the average growth rate for the developing world (2.6%) (CIMMYT 1990: 60, 67). We attribute the success in improving maize yields to a strong, independently financed research program in the highlands; in the lowlands maize research has stagnated.

In 1948 the Ministry of Agriculture set up an experimental station in Saavedra, Santa Cruz, to research rice, sugar cane, and maize (Velasco et al. 1988: 10-11; Wennergren and Whitaker 1975: 250-251). With the backing of IAS, the station introduced and improved Cuban Yellow Corn, released improved seeds for commercial use in 1953-54, and provided credit and competent extension services. The new maize varieties in the lowlands more than tripled the yields of traditional varieties (Heilman 1982: 74). By 1965, 80% of the maize in Santa Cruz came from improved varieties developed by IAS (Velasco et al. 1988: 11; Zuvekas 1977: 56). Since Cuban Yellow Corn served as cattle feed, the diffusion of improved maize varieties helped to establish the cattle industry in the Bolivian lowlands and helped Bolivia become a net beef exporter (Heilman 1982: 74).

By the mid 1960s research on maize started to decline because IAS transferred the experimental station inn Saavedra to the Ministry of Agriculture and withdrew money and personnel from Bolivia (Wennergren and whitaker 1975: 254). Since then, research on maize in the lowlands has stagnated. Research on lowland maize revived in the mid 1970s with the creation of CIAT in Bolivia. CIAT injected money and personnel into agricultural research of lowland crops. Although private companies and the regional corporation of Santa Cruz (Corporación Regional de Santa Cruz, CORDECRUZ) give CIAT adequate financing (ISNAR 1989), CIAT has not developed a new, viable maize technology for the lowlands. 1/

Bolivia ignored research on highland maize until the early 1970s, when a consortium of private foundations based in Switzerland set up the Centro de Investigaciones Fitogenéticas de Pairumani (CIFP) in Cochabamba. Adequate salaries, strong leadership, and administrative continuity allowed CIFP to develop and disseminate high-yielding, improved maize varieties for human and for animal use, but mostly in the Department of Cochabamba (Word Bank 1990: 8). CIFP has released at least nine improved maize varieties

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12/ Although has recently launched two new lowland maize varieties, but it is still too early to evaluate their effect. Some private companies in Santa Cruz finance their own research on new hybrid maize varieties (Alan Bojanic, personal communication). We have not been able to explore this subject.

for highland cultivation. Virtually all maize for silage, 8% of maize for human consumption, and 22% of lowland maize for animal feed in Bolivia comes from CIFP varieties (Ibid.: 9)

3.3 Soybean research

Bolivia started to commercially produce soybeans in the mid 1970s after the collapse of the cotton market in Santa Cruz. The ruin pushed cotton producers and vegetable oil manufacturers to search for other oil-bearing plants which could also be used in factories designed to process cotton seeds. With the onset of commercial soybean production in Brazil in the 1970s, the decline of the cotton market in Bolivia, and the establishment of CIAT in 1975 in Santa Cruz, conditions were ripe for advances in soybean technology in Bolivia.

Bolivian scientists started to research soybeans in the early 1950s in the experimental station of Saavedra (Tejerina 1988a: 138). The United States supplied Bolivia with soybean germplasm for about two decades, but these plants, suited to the longer daylight of the summer in the United States, proved unsuitable for the lowlands of Bolivia. In the 1970s Bolivia started importing genetic material from Mexico, Brazil, and Argentina; these plants proved more productive in Bolivia because of their shorter daylight requirements. Unlike the varieties imported from the United States, the new varieties, particularly from Brazil, were designated for cultivation in winter and summer months.

Since the mid 1970s Bolivia has relied heavily on research carried out in the experimental station of Londrina (Brazil) by EMBRAPA (Empresa Brasilera de Pesquisa Agropecuaria). Since the ecological and climatic setting of Londrina resembles growing conditions in Bolivia, Bolivia has ridden freely on EMBRAPA's research (Nuñez 1989: 18). As is true with the research on most other Bolivian crops, Bolivia limits itself to importing genetic material from Brazil and testing it out for yields and resistance to pests and diseases before releasing it to seed companies for commercial production. The long waiting period to develop new soybean varieties (five to seven years), the high risks and costs of developing new varieties, and the shortage of qualified personnel to carry out genetic experiments at CIAT have made CIAT import rather than develop its own soybean technology.

Over the past fifteen years CIAT has done systematically good adaptive research on soybeans and has consistently releasing improved varieties. For instance, during the early 1980s CIAT released two important soybean varieties, Cristalina and UFVl. By 1984, CIAT released IAC8, a new variety with a slightly higher stem (and therefore lower harvest losses) suitable for cultivation in winter and in summer. Under average growing conditions IAC8 yields more than the older varieties. By 1986 CIAT released Doko, which improved yields by 10% and spread fast among producers. Adoption rates for new soybean varieties have been high; 50% adoption rates within two years are common. CIAT has not only released new soybean varieties, but has also developed technological packages to accompany the new varieties. The packages include recommendations on application of new herbicides, soil management, date and density of planting, inoculations, pest control, and calibration of machinery.

A recent study of returns to investments in soybean research in Bolivia (Bojanic and Echeverría 1990) shows that soybean production in Bolivia increased from 100 thousand mt during the mid 1980s to 250 thousand mt at the end of the decade. This is explained mainly by area increases, from 60 thousand ha to 140 thousand ha during that period. Soybean yields increased from 1.2 mt/ha in the mid 1970s to over 2.0 mt/ha in 1990. Bojanic and Echeverría (1990) attribute the increase to favorable markets (higher product price in Bolivia given the 1986 change in domestic policy to an open market); and to intelligent borrowing of technologies from Brazil. The rate of return on soybean research in Bolivia during 1974-1989 was 70%, taking into account (and subtracting) the contribution of Brazilian varieties. The principal reasons explaining such a high return were: the rapid expansion of the crop, the availability of technology in Brazil, the effective role of CIAT in introducing new varieties, the role of the seed certificacion service, the continuity of research personnel and the stability of research funds through time, and the timely availability of a technological package. The study also shows that most of the research payoffs were captured by producers, which explains their funding for such activities.

3.4 Wheat research

Farmers in Bolivia produce wheat with two different technologies, in two non-contiguous areas, for two different ends. In the valleys of Cochabamba, Chuqisaca, Potosí, and Tarija smallholders using traditional technology produce soft wheats for their own use (40%), chicha (17%), local flour mills (10%), and for sale (21%); they set aside 12% of the production for seeds (Thompson 1986: 5). Native varieties are soft , tall, slow-growing, and unsuited for commercial milling. In contrast, in the lowlands, in Santa Cruz and in Tarija, Mennonite and Bolivian farmers cultivate semi-hard winter wheat exclusively for sale to mills. Unlike maize, and like most other agricultural commodities in Bolivia, wheat yields have stagnated during the past thirty years. During 1963 to 1975, Bolivia's wheat yield reached 0.7 mt/ha (Monnerat 1977: 9); by the 1980s, yields remained the same (Table 3). The authors of a study done in the mid 1970s showed that 38% of Bolivia's wheat production came from improved varieties. The estimates in Table 3 suggests that by 1990 the share of production from improved varieties had declined to 26%.

National programs to spread new wheat varieties in the highlands have failed (Rodríguez 1990: 6; Monnerat 1977). The stagnation, if not involution, in yields can be traced to an national research program on wheat and to agricultural policies hindering the diffusion of modern varieties. The Bolivian government has approached wheat research with ambivalence. In public, government officials want Bolivia to attain wheat self-sufficiency, but in practice they have accepted with equanimity cheaper, subsidized wheat imports from the PL 480 Program. Undecided about the role of wheat in the national economy, the government has had a correspondingly undiscerning and erratic research program on wheat.

Wheat research started in the late 1940's and early 1950's under the umbrella of IAS. The early research produced improved, rust-resistant wheat varieties for the lowlands (eg, Coposo, Chinoli 70, Jaral). Some of the new semi-hard varieties doubled the yields of traditional varieties and enjoyed a favorable market because they milled well; yet most of the new varieties released by IAS had a small effect on wheat yields (Wennergren and Whitaker 1975: 251-255; Monnerat 1977: 21-23; Moscardi 1977: 6; Zuvekas 1977: 39, 56). By the early 1960s research declined as IAS withdrew funds and personnel from Bolivia.

After the mid 1960s the government tried to revive wheat research. Although economic studies had shown that pricing policies would make a wheat program lose money, particularly when compared to research into livestock management, USAID unexplainably increased funding for wheat research (Wennergren and Whitaker 1977: 586) USAID money allowed researchers from Utah State University to continue improving wheat varieties. Researchers imported wheats from around the world, tried them in Bolivia's principal what producing areas, tested them for fertilizer response, and certified and released the most promising varieties to farmers , but adoption was low (Ibid.; Heilman 1982: 87-88). In 1969 the government created a National Wheat Program. During the early 1970s, the government established a new research station in San Benito (Cochabamba) and started the Abapó-Izozog project to produce irrigated wheat (Moscardí 1977:4). For unknown reasons the government discontinued the National Wheat program in 1977 (Justiniano et al. 1990: 53). The contract with Utah State University ended in the mid 1970s (Zuvekas 1977). The Abapó-Izozog program fared poorly because of high costs and poor management (Thompson 1986: 6; Zuvekas 1977: 48). By the early 1980s Bolivia once again lacked a research program on wheat.

In 1982 CIAT took over research on wheat in the lowlands. In recent years the National Association of Vegetable Oil Producers (Asociación Nacional de Productores de Oleaginosas, ANAPO) and CIAT have started to assess the status of wheat research in Santa Cruz, fueled by the prospects of developing wheat into a routine winter crop for soybeans. Financed by ANAPO and by the regional corporation of Santa Cruz, CIAT's research on lowland wheat has been recently strengthened. In 1990 CIAT put eight new professionals to work on wheat alone.

Wheat research in Bolivia since the early 1970s has produced mixed outcomes. In the lowlands, CIAT has had impressive results in recent years. Every two to three years CIAT releases a new variety which enjoys rapid and wide acceptance. In 1987-88 CIAT released Chané, which today occupies half of the area under wheat cultivation in Santa Cruz. In 1989 CIAT released Agua Dulce; at present, a quarter of the area sown with wheat in Santa Cruz is under this variety.

In the highlands IBTA conducts all wheat research, principally in the experimental station of San Benito Cochabamba. Within San Benito, wheat receives lower priority than fruit trees. IBTA and CIAT only import, test, and multiply wheat varieties; they do not breed varieties adapted to Bolivia's different ecologies. Wheat research has fared poorly in the highlands. The new varieties (eg, Chinoli, Totora 80, Esperanza, Tarata 80) have not made inroads among smallholders. At least three reasons explain the low rate of adoption of high-yielding wheat varieties in the highland. First, improved wheat varieties released by IBTA in the highlands have generally been of the dwarf kind (eg, Clizeño, Togo, Sacaba). Like farmers elsewhere in the developing world, Bolivian farmers dislike some dwarf wheat varieties because they produce small amounts of stubble and forage, valuable by-products to poor smallholders, especially if they practice common-field agriculture (Lipton and Longhurst 1985: 9; Zuvekas 1977: 56). 1/

The second reason for the limited adoption of high-yielding wheat varieties is that buyers reject them because they are unsuitable for commercial milling. Lastly, food donations from abroad have reduced the incentives among smallholders to increase commercial wheat production (Byerlee 1987: 322). The decline in food production brought about by the Revolution of 1952, the land reform of 1953, and the fiscal and macroeconomic chaos of the mid 1950s created food shortages in the cities and mining camps. So parlous a state of affairs, USAID argued , could only be corrected by supplying Bolivia with regular food donations. In the early 1960s the United States started dumping a steady tonnage of American wheat in the Bolivian market. 1/ Since the government sold food donations at subsidized prices, it reduced the interest of farmers in producing wheat (Justiniano 1990: 78). In the mid 1970s Moscardi showed that the Bolivian government sold imported wheat at 25% less than the world price (1977: 7). From 1976 until 1986 imported wheat from the Pl 480 program sold, on average, for 20% less than domestic wheat (Thompson 1986; 27-28). Wholesalers also wanted foreign wheat because they received a three month interest free loan when buying it (Ibid. 31-32; UDAPE 1988: 24).

In recent years the government has tried to remedy many distortions hurting the domestic wheat market. A decree in 1987 freed the market, making it obligatory to sell PL 480 wheat in Bolivia at world prices. In 1989 the Bolivian government reduced its subsidies on rail transport for PL 480 wheat from 30% to 10%, thereby lowering the disparity in price between Bolivian and foreign wheat.

3.5 Modern and traditional technologies compared

Following Barker and his colleagues, we classified and agricultural technology as modern if farmers use an improved seed variety (Barker et al. 1985: 143). New varieties require modern complementary inputs, such as fertilizers and pesticides. Because of limited research funds and time, we were not able to study hybrid technologies--traditional seeds plus modern inputs, for instance--or the optimal sequence of adoption.

Table 4 summarizes the major differences in production, area, yields, and costs for the modern and for the traditional technologies under study. Since the Ministry of Agriculture does not subdivide the

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13/ Field work in Cochabamba suggests that the sale of wheat by a smallholder yields a gross revenue of Bol$570/ha. Therefore, a dwarf variety producing no aftermath reduces the gross income of a smallholder by about 20%. The authors of three studies in the mid 1970s show that improved wheat varieties in the highlands raised farmer's income by a small amount (Monnerat 1977: 49; Wennergren and Whitaker 1977: 568; Zuvekas 1977: 56).

14/ Wilkie noted: "flooding of the Bolivian market with American agricultural commodities did indeed prevent a social crisis arising from lack of Bolivian food production, but it also had economic ramifications in that wheat production collapsed..." (1969: 14).

production statistics of a crop by the technology used, we relied on field work to infer how much land and production could be attributed to different technologies. A more complete discussion of how these estimates were calculated may be found in De Franco and Godoy (1991).

Modern technologies account for a small share of the area and the production of Bolivian agriculture but they have lower costs and higher yields than traditional technologies. For example , the new soybean technology improves yields by about 16%; the new maize and what technologies more than double yields. The modern potato technology triples the yields of the traditional technology and brings it on a par with the potato yields on Chile. On the cost side, the new technologies for potatoes, maize, soybeans, and wheat lower the variable costs of production by the following percentages: 6.5, 7.5, 28, and 51.

If modern technologies surpass traditional technologies in variable costs, as field work information shows, why have they achieved such limited distribution? We found modern technologies in small pockets--maize in Cochabamba, potatoes in Cochabamba's high valleys, winter wheat only in Santa Cruz's soybean fields--because agricultural researchers have not developed and adapted the technologies to Bolivia's other ecologies. Research has been done only in Bolivia's best lands, having by-passed farmers outside of Santa Cruz and Cochabamba's best valleys. The poor quality of agricultural extension and Bolivia's cultural balkanization may also slow the diffusion of new plant varieties, even if they could thrive outside the Cochabamba-Santa Cruz axis.

As de Janvry and Dethiers predict, the most important advances in agricultural technology have been confined to export crops. Bolivia has made important advances in the technology for producing soybeans, rice, winter wheat, and fodder maize in the eastern lowlands, the natural niche for commercial agriculture. The crops are exported or, like winter wheat, help to produce better soybeans. The development of new technologies for essentially non-traded staples has lagged from neglect (eg, potatoes) or from policies which have depressed domestic prices and lowered the farmgate profits of adopting new varieties (eg, wheat) (Zuvekas 1977: 67-68).

4. Conclusions

De Janvry and Dethiers's model of agricultural research bias helps to explain why research took the shape it did in Bolivia, but it does not explain why the government has so consistently ignored research, why producers of export crops have circumvented the government instead of pressuring it, and why Bolivian agricultural researchers have not brought about change.

Table 4. Comparison of modern and traditional technologies for selected crops

	Modern	Traditional
Potatoes		
Share of total production (%)	24	76
Share of total area (%)	10	90
Yields (mt/ha)	12	4.1
Full/time worker equivalent per year	2,200	59,000
Unit costs: (US$/mt)	126	136
Maize		
Share of total production (%)	19	81
Share of total area (%)	10	90
Yields (mt/ha)	2.5	1.22
Full/time worker equivalent per year	10,000	75,000
Unit costs: (US$/mt)	109	153
Soybeans		
Share of total production (%)	24	86
Share of total area (%)	12	88
Yields (mt/ha)	2.3	1.89
Full/time worker equivalent per year	61	450
Unit costs: (US$/mt)	114	122
Wheat		
Share of total production (%)	26	74
Share of total area (%)	15	85
Yields (mt/ha)	1.2	0.6
Full/time worker equivalent per year	102	5,500
Unit costs: (US$/mt)	130	267

[a] 1 US$ = $B 3.15n.a = not available ha = hectare

Bolivia's halcyon days of agricultural research came in the 1950s when the state, acting from above, decided to cater to the needs of newly enfranchised peasants by, among other things, improving agricultural technology. With foreign aid, rising food prices in the aftermath of the 1952 Revolution, and the threat of peasant and urban unrest, the government moved swiftly to establish agricultural research by collaborating with IAS. With the end of the perceived crisis and the withdrawal of IAS from Bolivia, public interest in research withered. Since then, almost all relevant agricultural research has been done by an independently financed, non-government organization (CIFP) and by CIAT, which is almost fully funded by the regional development corporation and private producers. IBTA has had good research results only in a very limited number of commodities.

As de Janvry and Dethiers predict, producers of export crops in Bolivia are fewer in number, are concentrated in Santa Cruz, and have a close knit social network. In contrast, producers of Bolivia's non-traded staples live scattered in lilliputian plots in the highlands and valleys, speak different language of those in power, and so find it difficult to lobby for public investments in agricultural research. Highland maize is the only smallholder staple enjoying good research, but thanks mainly to the individual initiative and commitment of a small cohort of Bolivian scientist and financial independence.

Since the early 1960s the state has not acted from above, has not acted from below, and has not been pressured from scientists lobbying for change. *The state does not act from above* for at least three reasons. First, it no longer faces a perceived agricultural crisis, as it did in the 1950s. Second, Bolivian policy makers may not realize the value of agricultural research and, so, cannot impose it from above. The early purveyors of agricultural research in Bolivia neglected to educate statesmen about the merits of investing in agricultural technology. Inspired by the Bohan Mission, IAS in the early 1950s grafted an agricultural research apparatus onto Bolivia's landscape without adequate proselytizing. Foreigners staffed, financed, and ran the institutions. When they left, the institutions corroded because researchers had not build political support for their work.

Lastly, the state cannot act from above because the outside world is not forcing it to do so. In fact, foreigners may have sent unclear signals to Bolivia about the value and the means of doing agricultural research. Like Bolivian statesmen, foreign agencies have also been ambivalent about investing resources in research projects which take many years to bear fruit.

The impulse to develop Bolivia's agricultural research came during the second world war, when the United States pressed Bolivia to do agricultural research because the United States wished to increase the production of selected crops among its Latin neighbors. With peace the urgency vanished; the United States deflected aid to rebuild Europe and fight the war in Korea, instead of supporting established agricultural programs and training in the Americas. During the 1960s, as part of the Alliance for Progress, foreign aid went to Bolivia to contain communism; much aid went to non-economic activities, such as support for the budget of the central government and the military, rather than for agricultural research or its natural complements, rural education and health (Wilkie 1969: 8-10). Today much of the financial assistance from the United States goes to substitute coca with other crops and to extirpate drug production. The fear of fascists, communists, and drug lords, have guided in a jumbled fashion foreign aid programs in Bolivian agriculture. These programs have lacked a coherent vision about the role agricultural research and technological innovations could play in Bolivia's economic growth.

The private sector does not pressure the government to do research for at least two reasons. First, because the central government does not value research it allocates small funds for this activity, does not levy export taxes for research, and does not lobby the international community for transfers. Domestic pressure groups, facing a depleted government purse for agricultural research, circumvent the government altogether and fund their own research through producer's voluntary contributions to CIAT. The second reason why private exporters do not lobby for research relates to regional cleavages. Exporters in the past have received concessional credit and tax advantages from the central government, but only when key policy makers came from Santa Cruz and, therefore, responded to their demands. At other times, requests from Santa Cruz exporters have not been heard by highland policy-makers. By default, lowland exporters finance adaptive research themselves utilizing results from neighboring nations.

Scientists are an ineffectual pressure group because the turnover of professionals is high due to financing variability. Scientists do not stay long enough in a post to make it worthwhile for them to lobby for change. The only center capable of pressuring the government for change--Pairumani in Cochabamba--is unlikely to do it because they enjoy independent financing.

It is unclear how Bolivia will build the political backing for a research program on staples given the economic, social, and cultural constraints just discussed. In the short and medium run, outside pressure from institutions such as the World Bank will help to set up the foundations for a research system, but these efforts may not survive once donor funding ends because there is no political will underwriting these programs. We suggest that foreign aid in the form of grants and loans go into a trust fund so research centers operate out of the interest earned from the capital. This will allow to make long-term research plans and avoid sole reliance on the government or foreign donors. A research establishment operating out of an endowment with supplementary funds from the government or foreign aid agencies will naturally be smaller than a research system operating as a project. But in the long run, a small, endowment-based institution is likely to have a larger impact because it will be able to do long-term research, something which Bolivia has yet to do.

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