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Chile's Agricultural Diversification

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Chile's Agricultural Diversification. By Amy L. Sparks and Carlos A. Arnade. Commercial Agriculture Division, Economic Research Service, U.S. Department of Agriculture. Staff Paper No. AGES-9528.

Abstract

Chile's agricultural sector has dramatically expanded and diversified both production and exports in the past 30 years. Previously reliant on annual crops and wool, it is now a strong competitor in international fruit markets, apples and table grapes especially. Its success stems from a shift in consumption toward fruits and vegetables, natural resources suitable for fruit production, and government policies that encouraged farmers to switch to fruit. The industry is now moving toward production and export of pears, peaches and other stone fruit, as well as berries and melons, in addition to apples and table grapes. In diversifying with non-traditional crops, Chilean producers reduce risk.

Keywords: Apples, table grapes, grapes, pears, peaches, dry beans, lentils, wool, copper, diversification, risk, decision criteria, index of concentration, coefficient of variation, export unit value, perennial crops, annual crops, risk aversion.

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Summary

Chilean agricultural exports totaled nearly \$1.9 billion in 1993, comprising 21 percent of Chile's total exports. Since the early 1960's, the mix of Chile's farm exports has changed. Thirty years ago, nearly half of its farm exports were dry beans, lentils, and wool. Now dry beans, lentils, and wool account for less than 15 percent. Apples and table grapes together comprise approximately 70 percent of Chile's agricultural exports.

Fresh fruit exports account for 34 percent of the total value of Chilean exports, with a large proportion composed of apples and table grapes. In the 1960's, producers saw that their traditional exports of dry beans, lentils, and wool were fluctuating greatly in value from one year to another, whereas some nontraditional exports (apples and grapes) had relatively steady prices. As a rational reaction to market conditions, there was an increase in production and export of fruit. Chile's Southern Hemisphere location gives it a natural marketing window to the United States and the European Community, since its agricultural commodities are harvested during their winter, when domestic fresh fruit is scarce.

The initial shift of Chilean producers toward fresh fruit, especially apples and table grapes, is now undergoing a further shift in the mix of fruits offered, with increasing quantities of pears, peaches, nectarines, and other stone fruits, as well as berries and melons. This second round of diversification may be a rational reaction by producers to fluctuating world prices for their commodities.

The shift toward fruit exports was also facilitated by a number of domestic changes:

- Political stability since 1974 and enforcement of property rights encouraged Chile's landowners to make longrun investments. As a result, farmers diversified from annual crops and wool to perennial crops.
- Liberalization of the economy and loosening of export controls gave Chilean producers better access to technology and international markets.
- Growing use of tractors and fertilizer for grain production increased yields, freeing farmland for growing fruit.
- Consumer demand for fruits in developed countries rose due to rising incomes and also, perhaps, because of the increasing recognition of the value of a variety of fruits in a healthful diet.

Even with diversification into fresh fruit, yields rose for some of the country's important cereal crops. The area devoted to wheat fell 40 percent between 1962 and 1992, but total wheat production rose by 35 percent. An even more dramatic shift came in corn production, where area expanded by 28 percent but total production rose by 298 percent.

Chile's Agricultural Diversification, 1962-93

Amy L. Sparks and Carlos A. Arnade

Introduction

Diversification of the agricultural sectors of less developed countries into and within horticultural production can make a significant contribution to their economies by providing employment and foreign exchange. Horticulture is an area of agriculture which will grow as world income grows, because demand for these products is relatively sensitive to changes in consumer income. In addition, consumption of fresh fruits and vegetables has increased markedly, perhaps because of rising concern with health and nutrition (Islam, 1990).

To take advantage of these trends and characteristics of the horticultural sector, entrepreneurs in Chile have pursued an aggressive policy of agricultural diversification through the expansion of fruit production for export, particularly to the United States and Western Europe. Agriculture's share of the value of total Chilean exports increased from 7.4 percent in 1962 to 21 percent in 1993 (table 1). While agricultural exports were expanding, Chile's copper exports, although increasing in total quantity, declined in their share of the total value of exports from 66 percent in 1962 to 29 percent in 1993. Within agriculture, fruit has accounted for much of Chile's export growth. Approximately 13 percent of Chilean agricultural exports in 1962 were fresh fruit; by 1993, the proportion had risen to 34 percent. Most of Chile's fruit exports are apples and table grapes, which together amounted to 28 percent of fruit exports in 1993. Exports of pears and fresh stone fruit are also growing in both quantity and value. However, their share of fruit exports declined from 1962 to 1993. Production and export of other fruit such as berries and melons are also growing.

The specific objectives for this report are:

- (1) To discuss the growing diversification of Chile's exports.
- (2) To provide a descriptive analysis of the Chilean agricultural sector and discuss factors which have aided in its development.
- (3) To establish a general set of economic criteria for determining, at an aggregate level, whether risk is considered in production and export decisions.
- (4) To apply these decision criteria to Chile's fruit sector to evaluate whether its growing diversity is consistent with maximizing producer welfare when accounting for expected incomes from undertaking an enterprise and the income risk associated with that enterprise.

Table 1--Value of Chilean exports, selected years

Product	1962	1975	1982	1985	1988	1993
\$1,000 U.S.						
Total	532,082	1,648,707	3,579,005	3,674,121	6,794,219	9,068,686
Copper	352,940 (66.33) ¹	954,508 (57.89) ¹	1,246,175 (34.82) ¹	1,476,749 (40.19) ¹	2,565,552 (37.76) ¹	2,646,061 (29.18) ¹
Agriculture	39,422 (7.40) ¹	177,589 (10.77) ¹	631,912 (17.66) ¹	791,209 (21.53) ¹	1,355,362 (19.95) ¹	1,904,053 (21.00) ¹
Fruit	4,257 (13.80) ²	34,649 (19.51) ²	202,080 (31.98) ²	305,755 (38.64) ²	509,070 (37.56) ²	652,438 (34.27) ²
Grapes	1,491 (35.02) ³	13,601 (39.25) ³	95,237 (47.13) ³	184,335 (60.29) ³	274,816 (53.98) ³	327,481 (50.19) ³
Apples	876 (20.58) ³	15,362 (44.34) ³	77,867 (38.53) ³	66,433 (21.73) ³	124,071 (24.37) ³	131,843 (20.20) ³
Pears	295 (6.93) ³	2,334 (6.74) ³	12,008 (5.94) ³	11,424 (3.74) ³	26,170 (5.14) ³	53,967 (8.27) ³
Fresh stone fruit	880 (20.67) ³	3,342 (9.65) ³	14,273 (7.06) ³	38,620 (12.63) ³	57,015 (11.20) ³	89,670 (13.74) ³
Other fruit	715 (16.80) ³	10 (0.03) ³	2,695 (1.33) ³	4,943 (1.62) ³	26,997 (5.30) ³	49,477 (7.58) ³

¹Percent of total exports.²Percent of agricultural exports.³Percent of fruit exports.

Source: United Nations trade data matrix.

A History of Chile's Expanding Fruit Sector

From the mid-1960's until 1973, Chilean government policies regarding land reform and land expropriations were somewhat discretionary. With minimal security of property rights, farmers made few long-term investments in perennial crops. Agricultural production centered on several annual crops and wool.

However, Chile's major policy reform, initiated in 1974, assured producers that free-market principles would operate throughout the economy, including landownership. This allowed agriculture to become attractive for long-term investments. As a result, Chile's agricultural sector, which had been primarily centered around wool, beans, and grain, diversified significantly as farmers began large-scale investment in fruit plantings. Given Chile's natural endowments, fruit can be grown at competitive costs.

After 1974, Chile began to export apples and table grapes in significant quantities. Its Southern Hemisphere position allows Chilean exporters to market these commodities during the "off" season in Northern Hemisphere countries, when prices of these fruits are particularly high.

Another round of diversification is under way as farmers move into production of pears, peaches, nectarines, and other stone fruit. Exports of these products are expanding (Sparks and Bravo-Ureta, 1992).

This second round of diversification within the fruit sector may also be an attempt to mitigate the effects of variation in world prices for fruit crops. If that is the case, there is incentive to diversify to lessen fluctuations in export earnings. One objective of this report is to ascertain if indeed risk, in terms of export earnings fluctuations, is considered when deciding which crops to produce.

Several reasons have been given to explain the rapid growth of Chile's fruit sector. Fruit production often requires capital investments that pay off only in the long run. The country's political stability since 1974 and guaranteed enforcement of property rights allowed Chile's property owners to make longrun investments. Second, liberalization of the economy and a loosening of export controls gave Chilean producers better access to technology and international markets. Free-market policies pursued since 1974 may have allowed Chile to discover where it had a comparative advantage. Third, in developed countries, consumer demand for fruits increased as health considerations have become more important to consumers. Fourth, the growing use of capital inputs, fertilizer, and seed for grain production increased yields, thus freeing agricultural land in Chile for other uses. A fifth reason, which we discuss in detail, is that Chilean producers have continued to move into additional types of fruit production to reduce the risk associated with relying on a limited number of export crops.

Other driving forces behind the continued diversification of the fruit sector include making more efficient (profitable) use of the infrastructures that were built to handle apples and table grapes. These include roads, storage and packing facilities, and shipping facilities. Another major factor is the need to make more efficient (profitable) use of Chile's rural labor force by employing it over a longer production season. Diversification employs workers during the Chilean spring season (U.S. fall) harvesting strawberries, raspberries, and other berries. It also employs them through Chile's fall (U.S. spring) harvesting peaches, apples, pears, and other fruit.

Land Use and Production Trends For Major Fruit Crops

Crops competing for Chilean farmland include cereals, legumes and potatoes, industrial crops, and fruit trees. The area used for fruit trees has shown the most rapid rate of increase of the product categories, going from 58,000 hectares in 1972 to 177,000 in 1992, a 205-percent increase (table 2).¹ Despite this major gain, fruit trees represented just over 15.5 percent of the total cropped area in 1992. The area used for cereals, the crop using the most farmland, peaked at 1 million hectares in 1962 but dropped to 694,000 hectares in 1992, a 31-percent loss. Nevertheless, in 1992, 61 percent of total cropped area was devoted to cereals. The area used to grow industrial crops showed a gain of 20,500 hectares in 1992 compared with 1962.

The area devoted to wheat experienced a fairly consistent downward pattern for a net loss of 40 percent of its 1962 level (table 3). The land used to grow corn increased by 22 percent. The area allocated for rice increased by 14 percent.

Despite the drop in land used for wheat, total production went from 970,000 metric tons to over 1.5 million, a 35-percent growth. This resulted from a 167-percent rise in yields, from 1.26 mt/hectare in 1962 to 3.37 in 1992. Corn experienced much more dramatic improvement in productivity. Its yields rose from 2.14 mt/hectare in 1962 to 8.51 in 1992, a 298-percent increase. Total corn production in that time period rose from 181,000 to 991,000 mt, a 448-percent increase. Total rice production rose from 79,000 to 134,000 mt, a 70-percent growth, partly as a result of a 47-percent increase in yields.

The data presented in table 2 show a marked shift, at the national level, of land away from cereals and toward fruit trees. Despite the rapid increase in land going to fruit production, this shift had no adverse effect on wheat, corn, or rice output. The considerable productivity gains exhibited by these crops made possible sharp increases in their production during a period of substantial movement of resources to the fruit subsector.

Figures 1 and 2 show fertilizer use in Chile in two periods, 1961 to 1974, when grain yields were rising and apple and table grape production were expanding, and from 1975 to 1992, when fruit production was well established. In both time periods, fertilizer use increased approximately threefold. This strong growth in fertilizer use contributed to rising grain yields and thus freed land that had produced traditional grain crops to produce apples and table grapes.

Tables 4 and 5 present the number of hectares devoted to area, output, and yields of individual fruits for selected years from 1965 to 1992.² Most of these fruits experienced a substantial increase in area planted, particularly during the 1980's (tables 4 and 5). As would be expected, Chilean fruit production also showed a marked increase from 1962 to 1992, with the largest gains in apples (up 586 percent) and table grapes (up 700 percent).³ Overall, grape production rose by only 2.8 percent, despite the surge in production of table grapes. This reflected a major shift away from plantings of wine grapes and toward

¹ Data for 1962 were not available.

² 1962-64 data are not available. Some data points from 1988 to 1992 are also not available.

³ The percentages for table grapes are calculated using 1973 and 1987 data, as 1962 data are not available. The final year available for table grape production is 1987.

Table 2--Land use in Chile, by major agricultural product categories, 1962-92

Year	Cereals ¹	Legumes and potatoes ²	Industrial crops ³	Fruit ⁴	Total
<i>1,000 hectares</i>					
1962	1,013	209.1	74.5	NA	1,297
1963	992	202.4	89.6	NA	1,284
1964	988	187.0	110.9	NA	1,285
1965	958	189.4	107.5	NA	1,255
1966	1,009	171.0	124.9	NA	1,305
1967	969	170.1	96.2	NA	1,235
1968	1,003	173.2	96.6	NA	1,273
1969	951	156.7	100.7	NA	1,208
1970	968	168.2	115.6	NA	1,251
1971	968	194.2	99.8	NA	1,262
1972	982	210.4	102.3	58	1,353
1973	785	177.5	65.7	63	1,091
1974	899	215.9	60.9	63	1,238
1975	970	176.5	101.3	65	1,313
1976	843	206.3	118.1	67	1,234
1977	929	238.1	120.2	69	1,356
1978	856	262.5	76.8	73	1,268
1979	884	274.8	91.8	76	1,326
1980	852	291.3	93.9	82	1,319
1981	724	289.0	65.8	91	1,170
1982	649	260.0	35.7	98	1,043
1983	636	194.1	41.2	104	975
1984	783	211.1	56.9	112	1,162
1985	800	200.1	83.3	122	1,205
1986	797	200.5	138.4	133	1,269
1987	875	210.6	119.3	145	1,345
1988	793	190.9	132.2	155	1,271
1989	804	156	128	169	1,257
1990	823	153	87	NA	NA
1991	707	180	82	NA	NA
1992	694	170	95	177	1,136

NA = Not available.

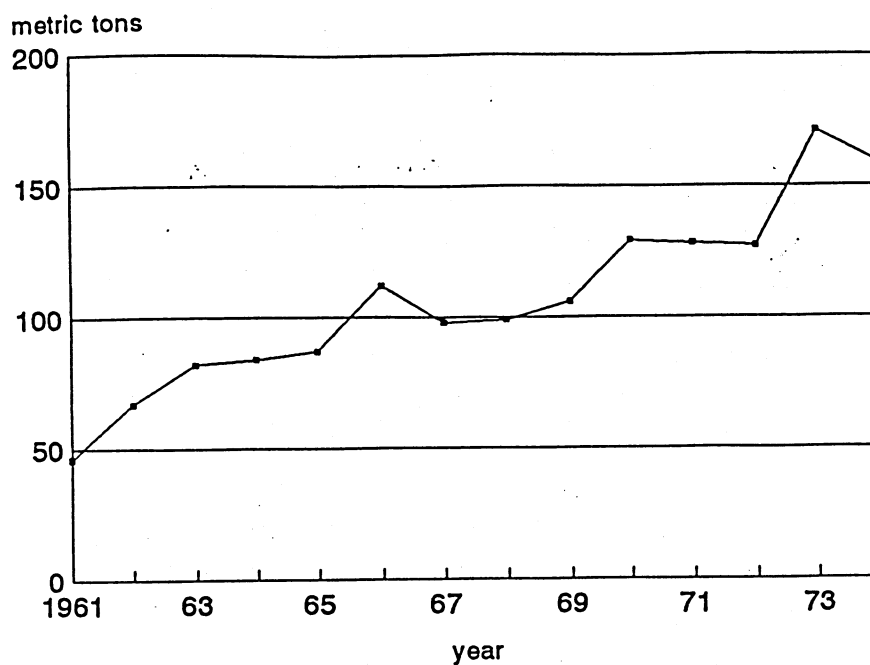
¹Wheat, barley, oats, rye, rice, and corn. ²Beans, peas, chickpeas, lentils, and potatoes.³Sunflower, rape, and sugarbeet. ⁴Almonds, cherries, plums, apricots, peaches, lemons, apples, kiwis, oranges, walnuts, olives, avocados, pears, and table grapes.Source: Central Bank of Chile. *Economic and Social Indicators, 1960-88*, Santiago, Chile.

Table 3--Area, total output, and yields for wheat, corn, and rice in Chile, 1962-92

Year	Wheat			Corn			Rice		
	Area	Output	Yield	Area	Output	Yield	Area	Output	Yield
	1,000 hectares	1,000 mt. ¹	MT/H ²	1,000 hectares	1,000 mt.	MT/H	1,000 hectares	1,000 mt.	MT/H
1962	769.8	970	1.26	84.6	180.8	2.14	27.7	78.5	2.83
1963	751.0	1,136	1.51	84.4	176.0	2.09	30.9	79.3	2.57
1964	748.2	1,159	1.55	88.2	241.5	2.74	30.6	80.4	2.63
1965	727.1	1,116	1.53	87.6	259.0	2.97	27.5	80.4	2.92
1966	780.0	1,346	1.73	80.7	285.3	3.54	36.9	76.7	2.08
1967	781.5	1,203	1.67	92.2	362.2	3.93	33.0	84.1	2.55
1968	698.4	1,216	1.74	88.8	320.8	3.62	32.5	93.5	2.88
1969	743.1	1,214	1.63	58.4	153.8	2.63	16.2	36.7	2.27
1970	740.3	1,307	1.77	73.9	239.0	3.24	25.2	76.2	3.02
1971	727.4	1,368	1.88	77.0	258.3	3.35	27.3	67.1	2.46
1972	711.8	1,195	1.68	84.5	283.0	3.35	25.7	86.3	3.36
1973	533.8	747	1.40	86.4	294.0	3.40	18.5	54.9	2.96
1974	591.0	939	1.59	107.4	366.3	3.43	13.2	34.3	2.63
1975	686.2	1,003	1.46	91.6	329.0	3.59	22.9	76.4	3.34
1976	573.8	712	1.24	109.4	283.0	2.59	30.0	96.7	3.33
1977	628.0	1,219	1.94	115.6	355.3	3.07	35.5	120.0	3.38
1978	579.6	893	1.54	93.9	256.9	2.74	47.1	104.8	3.21
1979	560.5	995	1.78	130.4	489.3	3.75	40.1	181.2	3.85
1980	546.7	966	1.77	116.2	405.2	3.49	40.8	95.4	2.34
1981	432.2	686	1.59	125.5	518.1	4.13	31.4	99.7	3.18
1982	373.8	650	1.74	107.1	484.0	4.52	37.0	131.2	3.55
1983	359.2	586	1.63	118.0	511.5	4.34	30.4	115.6	3.80
1984	471.3	988	2.10	138.4	721.4	5.21	39.9	165.0	4.14
1985	506.2	1,165	2.30	130.5	771.8	5.91	38.5	156.6	4.08
1986	569.2	1,627	2.86	104.7	721.3	6.89	32.0	126.7	3.96
1987	676.6	1,874	2.77	86.7	617.2	7.12	37.3	147.0	3.95
1988	576.6	1,734	3.01	90.3	660.8	7.32	38.9	162.2	4.17
1989	540.2	1,766	3.27	125.9	938.0	7.50	43.2	185.0	4.30
1990	583.2	1,718	2.95	101.8	823.0	8.15	33.1	135.0	4.12
1991	466.2	1,559	3.41	100.8	836.0	8.36	30.1	117.0	3.90
1992	461.2	1,557	3.37	107.9	911.0	8.51	32.1	134.0	4.18

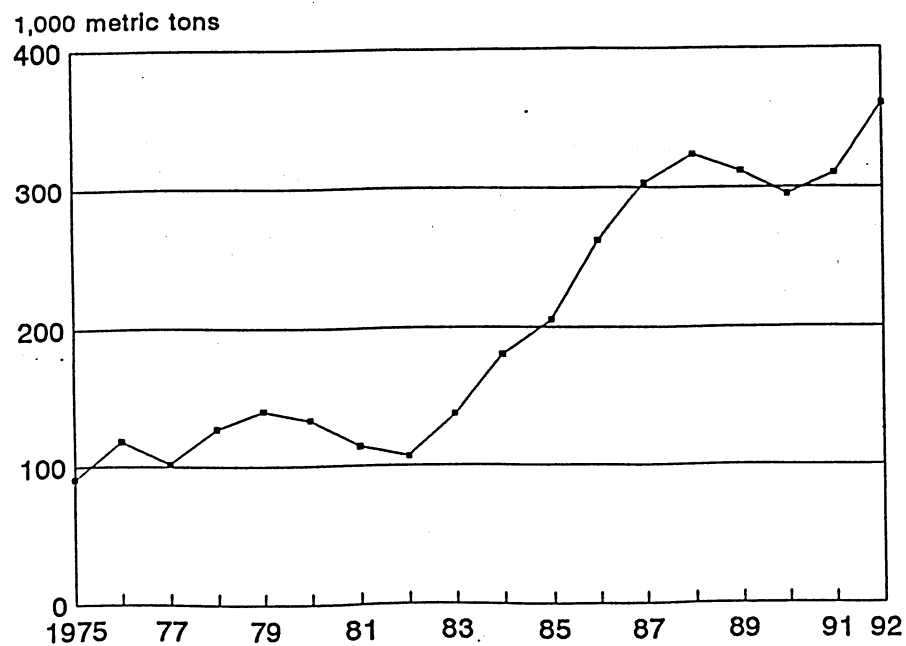
¹mt. = Metric tons.²MT/H = Metric tons per hectare.Source: Central Bank of Chile. *Economic and Social Indicators, 1960-88*, Santiago, Chile.

Figure 1
Chile's Fertilizer Use, 1961-1974



Source: United Nations, Food and Agricultural Organization, Fertilizer Yearbook

Figure 2
Chile's Fertilizer Use, 1975-1992



Source: United Nations, Food and Agriculture Organization, Fertilizer Yearbook

Table 4--Area, total output, and yields for apples, grapes, and table grapes in Chile, selected years

Year	Apples			Grapes			Table grapes		
	1,000 hec.	1,000 mt.	MT/H ²	1,000 hec.	1,000 mt.	MT/H ²	1,000 hec.	1,000 mt.	HT/H ²
1965	8.5	121	14.21	103	630	6.12	NA	NA	NA
1973	11.3	119	10.53	108	953	8.82	5.2	49.4	9.50
1974	11.4	120	10.53	106	808	7.62	4.3	52.8	12.28
1976	12.6	130	10.32	105.9	841	7.94	7.0	57.2	8.17
1978	13.8	175	12.68	100.5	955	9.50	10.3	68.4	6.64
1980	15.5	245	15.81	115	1,050	9.13	13.5	77.1	5.71
1981	16.9	289	17.63	125	1,100	8.80	16.0	110.6	6.91
1982	17.6	345	19.60	122	1,100	9.02	18.4	147.6	8.02
1983	18.1	365	20.17	121	1,100	9.09	20.9	178.2	8.53
1984	18.6	410	22.04	112	1,000	8.93	25.7	204.1	7.94
1985	19.2	425	22.14	108	1,050	9.72	30.6	250.6	8.19
1986	19.9	519	26.08	115	1,000	8.70	36.0	279.0	7.75
1987	21.6	580	26.85	117.6	963	8.19	38.8	335.7	8.65
1988	NA	630	NA	118	999	NA	NA	NA	NA
1989	NA	660	NA	118	1,037	NA	NA	NA	NA
1990	NA	700	NA	120	1,171	NA	NA	NA	NA
1991	NA	780	NA	121	1,186	NA	NA	NA	NA
1992	NA	830	NA	121	1,141	NA	NA	NA	NA

NA = Not available.

¹mt. = Metric tons.

²MT/H = Metric tons per hectare.

Sources: Area data: Chilean Ministry of Agriculture for all data except 1988 data, which are from the Fresh Deciduous Fruit Annual Report, U.S. Dept. Agr., Foreign Agricultural Service, Report code 0901: pp. 2-15. Production data: Apple and grape data are from the United Nations Food and Agriculture Organization. Table grape data are published by the Agricultural Planning Office, Ministry of Agriculture, Chile.

Table 5--Area, total output, and yields for pears in Chile, selected years

Year	Pears		
	1,000 hec.	1,000 mt.	MT/H
1965	2.8	24	8.57
1973	2.6	31	11.92
1974	2.6	33	12.69
1976	2.7	36	13.33
1978	2.8	38	13.57
1980	3.3	43	13.03
1981	3.6	46	12.78
1982	3.8	51	13.42
1983	4.1	57	13.90
1984	4.5	66	14.67
1985	4.8	71	14.79
1986	6.4	78	12.19
1987	7.6	84	11.05
1988	NA	99	NA
1989	NA	119	NA
1990	NA	140	NA
1991	NA	165	NA
1992	NA	180	NA

NA = Not available.

mt. = Metric tons.

MT/H = Metric tons per hectare.

Sources: Area data: Chilean Ministry of Agriculture for all data except 1988 data, which are from the Fresh Deciduous Fruit Annual Report, U.S. Dept. Agr., Foreign Agriculture Service, Report code 0901: pp. 2-15. Production data are from the United Nations Food and Agriculture Organization.

table varieties. The divergence between the rate of increase in plantings and production accrues, because it takes several years before these fruits come into full production. Yields for apples showed the strongest gain, going from 14.21 metric tons per hectare (MT/H) in 1965 to 27.51 MT/H in 1987, a 94-percent increase. Pears followed with a 22-percent increase and grapes, as a whole, a 38-percent increase. Table grape yields remained essentially unchanged.

Chile's Agricultural Exports

Three annual crops, dry beans, lentils, and wool, are important components of Chile's agricultural exports. The volume and value of the exports of these crops fluctuates, as in a business cycle. This can be seen quite readily in tables 6 and 7.

Chilean exports of apples and table grapes have steadily increased since 1961 (table 8). By 1976, apple exports were more than six times the 1961 levels. Between 1976 and 1991, the quantity of apple exports increased almost six-fold. Exports of table grapes followed an equally strong growth pattern, though the most rapid period of growth was somewhat later than that of apples. By 1976, table grapes were 3.6 times the 1961 level. Between 1976 and 1991, the quantity of table grape exports grew by a factor of 15.

Of the top five agricultural exports, dry beans, lentils, and table grapes, the value shares of exports of apples and table grapes have increased sharply since 1961, while those for dry beans, lentils, and wool have declined. Whereas apples and table grapes, combined, accounted for slightly under 12 percent of the value of Chile's top five agricultural exports in 1961, by 1993, together, they accounted for over 94 percent. Wool exports fell from 45 percent to just over 1 percent in 1993. Exports of dry beans fell from 22 percent of the value share of the top five agricultural exports to 4.4 percent. Lentils declined from 21 to 0.2 percent.

A rapidly changing agricultural sector, however, does not ensure that agricultural export revenues are any less variable after restructuring than before. The following sections discuss Chile's diversification path from the perspective of variation in export revenues.

Indicators of Concentration of Exports and Variation in Export Prices

Figure 3 plots indices of concentration for Chilean agricultural export products. The index represents the sum of the square of the shares of export values in each category multiplied by 100. If only one agricultural good is exported, this index equals 100. The greater the diversity of exports, the closer this index lies to zero.⁴ From 1961 to 1973, the pre-reform period, the index was virtually constant. From 1974 to 1977, Chile's agricultural exports were becoming less concentrated. By 1978, the index began to rise, reflecting Chile's increasing concentration of apple and table grape exports. The highest level of concentration was observed in 1985. After that time, Chile's exports of pears, peaches, and nectarines rose significantly and the concentration index fell. But it was still three times its lowest level in 1977, and considerably greater than in the 1960's. This reflects the trend discussed earlier whereby, while the agricultural sector as a whole was becoming more concentrated, the fruit subsector itself was becoming more diversified.

⁴ The concentration index is defined as: $100 \cdot \sum_i (x_i / \sum_i x_i)^2$ where x_i is the value of exports of good i .

Table 6--Volume of Chile's top agricultural exports, 1961-93

Year	Dry beans	Lentils	Apples	Table grapes	Wool
<i>Metric tons</i>					
1961	25,223	15,236	6,287	6,626	9,292
1962	19,533	9,950	7,497	7,536	5,949
1963	12,291	8,983	12,463	7,497	7,783
1964	18,508	15,627	12,533	9,612	5,518
1965	11,883	4,346	20,075	8,924	5,670
1966	6,318	1,746	21,841	9,739	6,738
1967	12,940	433	18,232	8,788	5,614
1968	13,000	2,000	20,853	13,385	8,873
1969	6,000	1,652	15,402	14,875	10,621
1970	12,000	6,000	18,899	15,861	8,847
1971	12,440	4,678	27,962	17,445	5,307
1972	11,390	1,007	23,905	15,452	0
1973	7,693	1,025	24,545	13,672	0
1974	27,497	7,908	29,203	17,151	1,897
1975	21,735	7,203	45,332	25,167	9,233
1976	14,705	6,158	73,575	30,774	9,217
1977	40,602	14,699	76,460	37,284	7,377
1978	55,363	14,246	116,122	51,055	10,390
1979	46,860	18,254	124,307	50,646	12,754
1980	50,017	14,549	178,478	49,603	10,661
1981	60,829	6,028	198,203	93,674	11,552
1982	44,703	4,488	198,476	125,718	12,524
1983	45,125	4,531	195,290	172,879	10,638
1984	21,428	3,049	226,945	178,421	9,067
1985	63,728	12,105	202,862	231,527	7,987
1986	62,148	16,695	312,807	231,294	9,347
1987	44,049	4,167	331,188	271,536	8,358
1988	70,828	5,496	347,336	349,941	8,442
1989	57,869	2,245	325,852	352,407	4,981
1990	59,801	113	314,305	471,181	6,358
1991	63,552	1,289	392,168	419,203	6,030
1992	73,374	2,186	417,429	428,516	4,158
1993	41,080	1,269	361,268	440,748	4,189

Source: United Nations, Food and Agriculture Organization, and United Nations trade data.

Table 7--Value of Chile's top agricultural exports, 1961-93

Year	Dry beans	Lentils	Apples	Table grapes	Wool
\$1,000 U.S.					
1961	3,900	3,729	749	1,323	8,161
1962	3,253	2,926	876	1,491	5,786
1963	2,195	2,666	1,432	1,316	8,237
1964	3,153	3,339	1,630	1,534	7,176
1965	2,238	862	2,418	1,517	5,486
1966	1,343	463	2,675	1,608	6,776
1967	2,211	116	2,205	1,572	4,681
1968	2,143	639	2,691	2,844	5,917
1969	1,170	390	2,366	3,384	8,035
1970	2,635	1,917	3,481	4,033	6,399
1971	6,744	1,749	4,802	4,519	3,570
1972	3,466	471	5,022	4,317	0
1973	2,876	557	6,441	4,327	0
1974	14,574	5,219	5,518	5,780	3,506
1975	7,486	3,807	15,362	13,601	9,521
1976	4,880	3,700	18,205	15,249	10,870
1977	15,096	8,553	19,674	19,554	12,194
1978	18,975	9,307	40,259	29,649	15,860
1979	21,100	12,300	43,100	44,700	22,200
1980	32,632	14,719	65,969	51,800	22,473
1981	40,730	5,700	76,100	69,756	19,518
1982	11,988	2,853	77,868	95,238	19,849
1983	12,886	2,604	63,115	116,636	15,481
1984	10,503	2,254	74,151	169,064	16,059
1985	25,929	8,247	74,264	215,595	11,534
1986	25,290	13,647	126,376	249,011	12,749
1987	18,384	2,350	141,887	275,714	12,804
1988	26,700	2,500	129,100	315,100	19,704
1989	38,400	1,400	110,400	282,000	14,500
1990	44,282	93	107,474	352,777	10,774
1991	31,929	1,062	153,770	301,026	7,412
1992	29,952	1,608	188,115	322,646	7,392
1993	21,411	914	131,843	327,481	5,173

Source: United Nations, Food and Agriculture Organization, and United Nations trade data.

Table 8--Percentage value shares of Chile's top five agricultural exports,
1961-93

Year	Dry beans	Lentils	Apples	Table grapes	Wool
<i>Percentage value shares</i>					
1961	21.8	20.9	4.2	7.4	45.7
1962	22.7	20.4	6.1	10.4	40.4
1963	13.9	16.8	9.0	8.3	52.0
1964	18.7	19.8	9.7	9.1	42.6
1965	17.9	6.9	19.3	12.1	43.8
1966	10.4	3.6	20.8	12.5	52.7
1967	20.5	1.1	20.4	14.6	43.4
1968	15.1	4.5	18.9	20.0	41.6
1969	7.6	2.5	15.4	22.1	52.4
1970	14.3	10.4	18.9	21.8	34.7
1971	31.5	8.2	22.5	21.1	16.7
1972	26.1	3.5	37.8	32.5	0
1973	20.3	3.9	45.4	30.5	0
1974	42.1	15.1	15.9	16.7	10.1
1975	15.0	7.6	30.9	27.3	19.1
1976	9.2	7.0	34.4	28.8	20.5
1977	20.1	11.4	26.2	26.0	16.2
1978	16.6	8.1	35.3	26.0	13.9
1979	14.7	7.8	30.1	31.2	15.5
1980	17.4	2.7	35.2	27.6	12.0
1981	19.2	1.4	35.9	32.9	9.2
1982	5.8	1.2	37.5	45.8	9.6
1983	6.1	.8	30.0	55.4	7.3
1984	3.9	2.5	27.3	62.1	5.9
1985	7.7	3.2	22.1	64.2	3.4
1986	5.9	.5	29.6	58.3	3.0
1987	4.1	.5	31.5	61.1	2.8
1988	5.4	.3	26.2	63.9	4.0
1989	8.6	.3	24.7	80.0	3.2
1990	NA	NA	NA	NA	NA
1991	6.4	.2	31.1	60.8	1.5
1992	5.4	.3	34.2	59.0	1.3
1993	4.4	.2	27.1	67.3	1.1

NA = Not available.

Figure 3
Indices of Concentration of Chile's Agricultural Exports

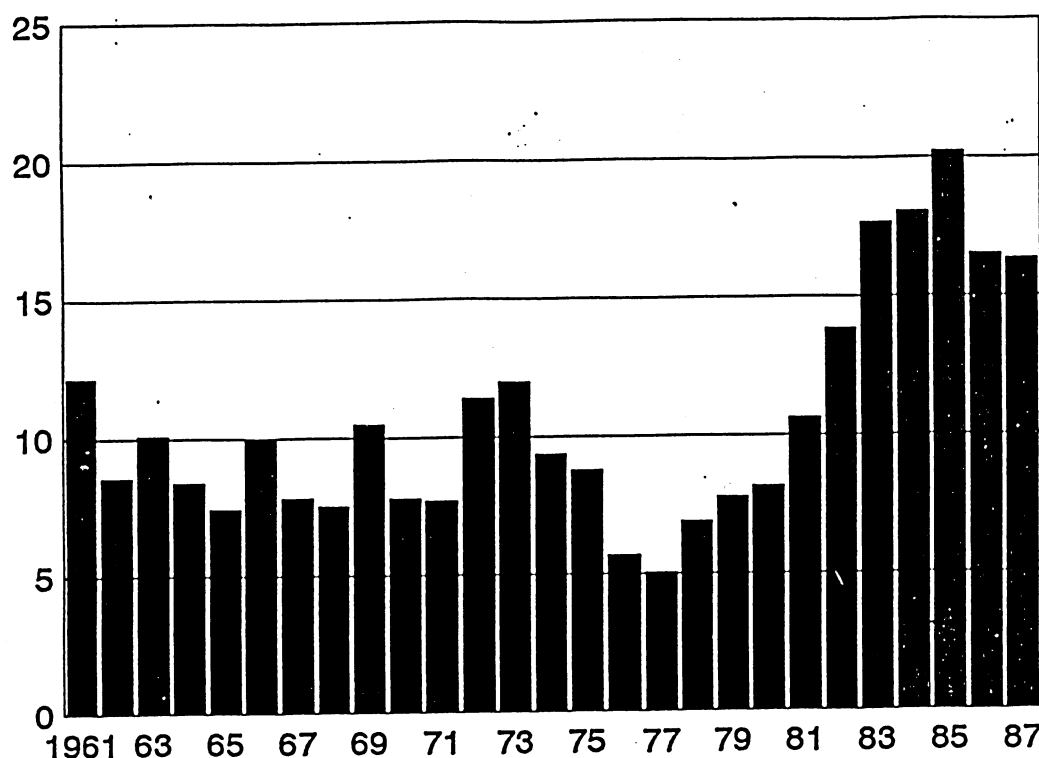
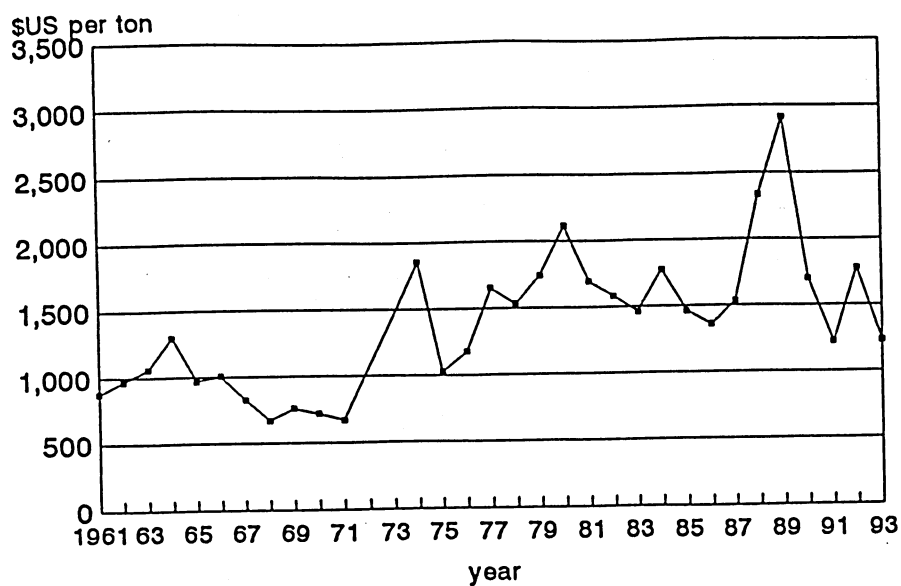


Figure 4 graphs the export unit value of Chilean wool from 1961 to 1993. A wide variation in wool prices in the 1960's is evident. The peak price for this decade was almost twice its lowest price. Dependence on wool exports for agricultural earnings invited a degree of risk and variability in export earnings. Figure 5 graphs export unit value of apples and table grapes. Values of these commodities over the 1960's, the decade in which Chile moved into production of these commodities, were more stable than those of wool. Prices of apples and table grapes varied little until the 1970's, after which Chile had moved into both production and export of these commodities. From figure 5, it is also apparent that once Chile began to export its new fruit crops in significant amounts, the variability of export unit values of table grapes rose significantly and that for apples noticeably.

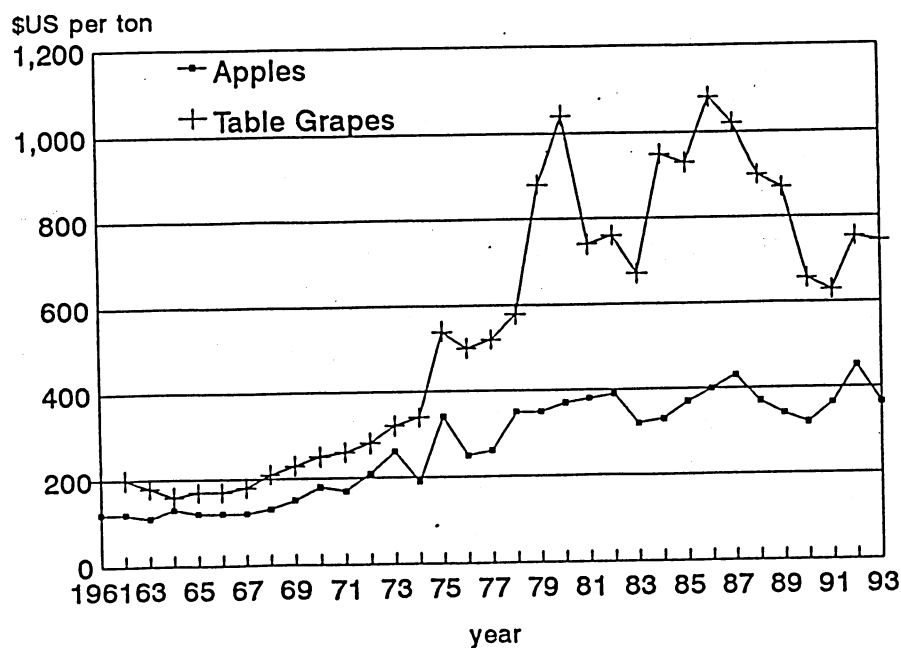
Table 9 presents the coefficients of variation (cv's) of free-on-board (f.o.b.) export prices for Chile's major agricultural exports. The higher the coefficient of variation for a particular commodity, the more fluctuations that will be experienced in earnings from its exports, assuming quantities are constant. From 1962 to 1967, Chile's traditional exports -- wool, lentils, and beans -- had the highest fluctuations in export earnings. Apples and table grapes had the lowest (table 9). If those coefficients of variation (cv's) are assumed to represent the income risk for exporting, the cv's for this time period indicate that a shift into production and export of apples and table grapes would have been consistent with reducing price instability. This assumes, of course, that there is a profit from apple and table grape production. Those were, in fact, the years when large-scale plantings of apples and table grapes began.

Figure 4
Chilean Export Unit Value: Wool



Data for 1972 and 1973 are simulated;
actual data for those years are unavailable.
Source: United Nations trade data matrix

Figure 5
Chilean Export Unit Value: Apples and Table Grapes



Source: United Nations trade data matrix

Table 9--Relative coefficients of variation of Chilean agricultural exports, selected years

Product	Price cv's ¹
<u>1962 to 1967</u>	
Beans	1.36
Apples	.19
Table grapes	.86
Wool	19.54
Lentils	5.50
<u>1968 to 1973</u>	
Beans	55.48
Apples	9.82
Table grapes	4.45
Wool	NA
Lentils	27.62
<u>1974 to 1987</u>	
Beans	33.00
Apples	12.03
Table grapes	67.99
Wool	44.28
Lentils	27.71

NA = Not available.

¹Prices are represented by Chile's export unit values.

²Due to missing data, coefficients of variation for wool prices from 1968 to 1973 are not available.

Source: Food and Agriculture Organization Trade Yearbook, 1962-87, and United Nations trade data.

In the time periods 1968 to 1973 and 1974 to 1987, the cv's for apples and table grapes were quite large, as were those for beans and lentils.⁵ These cv's indicate that further diversification would be, again, an economically rational step to reduce the variability of export earnings. During those time periods, Chile began large-scale plantings of pears, peaches, nectarines, and other stone fruit.

Table 10 presents an aggregate coefficient of variation for agricultural exports for the periods 1961 to 1971 and 1973 to 1989. These aggregate export unit values represent weighted sums. The top row represents the coefficient of variation of an aggregate export unit value for Chilean agricultural exports, with actual historical export shares serving as weights. The second row represents another weighted sum of export unit values. In this case, the 1961 export shares, where wool production represents 45 percent of

Table 10--Coefficients of variation for an aggregate unit value of Chilean agricultural exports, selected years

Item	1961-71	1973-89
Actual export composition	16.43	16.55
1961 export composition	27.39	26.03
Percent reduction	40.01	36.42

⁵Data were not available to calculate a cv for wool from 1968 to 1973.

the value of exports, serve as weights. The third row represents the percentage reduction in the aggregate coefficient of variation as a result of the restructuring of Chile's agricultural exports after 1961.

By diversifying Chile's fruit sector, the risk associated with export returns to agriculture was reduced (table 10). However, the reduction in aggregate export value was even more dramatic than indicated, since changing shares tends to magnify variability. For example, a high price of wool tends to increase the share of returns going to wool, and a low price reduces the share. Therefore, a flexible share-weighted index typically is more volatile than a fixed share-weighted index. Despite this, Chile's aggregate cv, with diversification of its agricultural sector into fruit production was significantly lower in both 1961 to 1971 and 1973 to 1989 than it would have been had Chile's exports maintained the same structure as in 1961.

All of the descriptive analyses presented suggest that the path of diversification followed by Chilean fruit producers and exporters was a rational response to variability in world prices. They also seem to indicate that Chilean farmers and exporters consider risk in their decisionmaking. In the following section, decision criteria will be derived from economic theory. These criteria will be used to conduct empirical tests to ascertain, at an aggregate level, whether risk was taken into account in the diversification of the fruit sector.

Decision Criteria

A preference function representing risk-averse decisionmakers can be written as a function of both profit and the variance of profit. The most standard representation of such preferences is:

$$U(\pi, \sigma_\pi) = \pi - (\Theta/2) * \sigma_\pi \quad (1)$$

where π represents profits, σ_π represents the variance of profits, and Θ represents the coefficient of risk aversion. The criterion for choosing to produce and export a nontraditional crop is, therefore, to compare the traditional viewpoint of profit maximization with the more general goal of maximizing utility. Arnade and Lee found that, when comparing two crops, a nontraditional crop with expected price P_n , and a traditional crop with expected price P_t , the nontraditional crop meets the utility-maximizing criterion if:

$$P_n/P_t > \text{COV}(P_t, P_n)/\text{VAR}(P_t) \quad (2)$$

where COV stands for covariance and VAR stands for variance.

Note that a negative covariance between the traditional crop price and the nontraditional crop price will ensure that the above condition holds. However, the condition can hold even when there are positive covariances between output prices of traditional and nontraditional crops.

Arnade and Sparks generalized this criterion to include numerous crops. When there are n possible crops, the general criterion for increasing the utility of a nontraditional crop is:

$$P_n/P_t > [\sum_{j=1}^{n-1} Y_j \text{Cov}(P_n, P_j)] / [\sum_{j=1}^{n-1} Y_j \text{Cov}(P_t, P_j) + \text{Var}(P_t)Y_t] \quad (3)$$

where P_i and P_j are prices of traditional crops, P_n is the price of a nontraditional crop, and Y_i are choice variables.

These criteria are used to measure whether Chile's fruit products have been produced and exported with utility maximization as a goal. However, Chile's diversification occurred in two stages. As already noted, in the 1970's, exports of apples and table grapes expanded. These exports supplemented and then came to dominate traditional exports. In the second stage of diversification, which is still occurring, Chilean producers began to grow and export pears and peaches. An even more general criterion is used to determine if peaches and pears fit diversification criteria. This more general criterion could be viewed as the requirement for increasing utility by diversifying a second time after producers have already diversified once.⁶

Implementation of these decision criteria yields insight as to whether the economic assumption of utility maximization was met when Chilean producers expanded into new products. Tables 11 through 14 present the results of applying these criteria to Chile. The tests were conducted several ways.

The two-good criterion (equation 2) was first evaluated. That is, each nontraditional crop was paired with each traditional crop to determine if introduction of the nontraditional crops would increase utility.

In table 12, apples were paired with beans, then lentils, and then wool. Grapes were also paired with beans, then lentils, and wool. Criterion 2 can be rewritten by writing equation 2 as the ratio of the left-hand side (the covariance-to-variance ratio) over the right-hand side (the price ratio) as being less than 1. The numbers in table 12 are represented in such a way. Therefore, a number less than 1 meets the criterion for increasing utility by diversification.

For example, using 1961 to 1965 data, when pairing apples and beans, this ratio is -0.16, so that a risk-averse bean producer would increase utility by growing apples. In this period, a producer of any traditional crop would increase utility by growing apples. For both apples and grapes, in each of the three time periods, when compared with exporting the existing traditional crops individually, the two-good criterion was met and aggregate utility was increased by exporting apples and table grapes.

The multigood output criterion, represented by equation 3, was also applied to Chilean agriculture. Again, for this condition, a number less than 1 indicates utility could be increased by growing the nontraditional crop. For example, in table 12, when apples are compared with wool, taking into account the existence of other crops, the criterion is met for the period 1961 to 1965 but not 1974 to 1979, nor is it met when apples are compared with beans and lentils. However, in the 1961 to 1965 time period, grapes meet the criterion when compared with any crop, but do not meet the criterion in the 1974 to 1979 period.

Thus, taking into account the existing diversity of exports, the general criteria hold for both apples and table grapes in 1961 to 1965 but not for 1974 to 1979. This last result suggests a possible motive for the more recent second round of diversification into peaches and pears.

The two-good and the multigood criteria were then used to evaluate the second round of diversification, in which production and exports of peaches and pears expanded rapidly. When the two-good world criterion

⁶ The criteria can be found in Arnade and Sparks and is too cumbersome to present here.

Table 11--Two-output criterion for apples and table grapes, selected years

Time period	Beans	Lentils	Wool
Apples with:			
1961-65	-0.16	-0.22	0.20
1967-73	.28	.84	0
1974-79	-.54	-.24	-.33
Table grapes with:			
1961-65	-.64	.32	-.50
1967-73	.24	.55	0
1974-79	-.16	.91	.12

Table 12--Multi-output criterion for apples and table grapes, selected years

Time period	Beans	Lentils	Wool
Apples with:			
1961-1965	1.87	1.34	0.37
1974-1979	4.00	4.00	1.91
Table grapes with:			
1961-1965	-2.00	-1.43	-.40
1974-1979	7.37	6.51	3.52

Table 13--Two-output criterion for pears and peaches, 1974-79

Fruit	Beans	Lentils	Wool	Apples	Table grapes
Pears	-0.40	0.93	0.04	0.81	0.66
Peaches	-.30	.57	-.03	.60	.45

Table 14--Multi-output criterion for pears and peaches, 1974-79

Fruit	Beans	Lentils	Wool	Apples	Table grapes
Pears	4.39	3.88	2.10	1.10	0.60
Peaches	3.16	2.79	1.51	.79	.43

is applied to pears and peaches against the already produced crops for 1974, to 1979, the criterion for increasing utility by diversification is met (table 13). The results are particularly relevant when pears and peaches are compared with apples and table grapes. Though the prices of pears and peaches are positively related to the prices of apples and table grapes, and they are not countercyclical crops, they still meet the criterion for expansion.

When applying the multi-crop criterion to pears and peaches, the multi-crop criterion holds only against apples and table grapes for the production of peaches and only for table grapes for pears (table 14). Producing peaches for export is justified only after apples and table grapes are established and producing pears for export is only justified after table grapes are established. This result suggests that the sequence by which nontraditional crops were chosen is consistent with maximizing a risk-averse utility function.

Conclusions

This report discusses the growing diversification of Chile's fruit sector. Numerous reasons are cited for its growth and development, including political stability and enforcement of property rights since 1974. Other factors include liberalization of the economy and loosening of export controls, along with an increase in demand by developed countries' consumers for fruit at least partially to health considerations. The theoretical aspects of this paper discuss diversification decisionmaking from the perspective of maximizing utility, which takes both profits and risks into account. Empirical application of the derived decision criteria indicates that, on an aggregate level, Chilean fruit producers are following the path of utility maximization.

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