CHAPTER V

ECONOMIC EFFICIENT ANALYSIS OF COFFEE PROCESSING FIRMS

This chapter analyses and discusses costs, revenue, and net return of coffee processing firms in the study area. Then programming models are used and applied to a cross-section of forty-five coffee processing firms in the Central Highlands of Vietnam. By following this method, a nonparametric approach, constrained and unconstrained profit frontiers are constructed. The foregone profit is evaluated as dual evidence for the existence of expenditure constraints. Specifically, a deterministic frontier profit function is constructed with and without expenditure constraints using a programming approach. This model has a multiple output and multiple input technology without constructing indexes.

A. COST AND RETURN ANALYSIS

5.1 Input structure in the firms interviewed

5.1.1 Types of coffee processing firms

According to technology classification, there are three types of coffee processing firms, viz. wet, dried, and mixed processing firms. I surveyed 45 coffee processing firms, of which the proportion of wet, dried, and mixed processing firms were 20%, 60%, and 20%, respectively. All 45 coffee processing firms surveyed are state firms. These firms differed slightly in the scale of investment (capital and labor) and processing. Each of wet processing firms had an input market area about 700-1000 hectares. Most coffee went to the state coffee processing firms where green bean coffee is made. After processing of green bean

coffee, the state coffee processing firms export either directly to importers in foreign countries or indirectly through domestic exporters.

5.1.2 Inputs structure in the firms interviewed

There are two major types of material inputs, namely berry coffee "cherries" and dried coffee beans. The average amount of coffee input per firm in 1998 was 6,022 tones of berry coffee and 926 tons dried coffee beans (Table 5.1).

Table: 5.1 Raw material inputs used per coffee processing firm in CHL, VN 1998

	Berry coffee		Dried coffee	
Kinds of firm	Quantity (tons)	Value (Mill.VND)	Quantity (tons)	Value (Mill.VND)
Wet processing	16,537	60,921	0	0
Dried Processing	2,565	8,739	1,326	23,610
Mixed processing	5,878	20,667	653	9,479
Average	6,022	21561	926	16,062

Wet and mixed processing firms used a higher proportion of berry coffee (16,537 tons and 5,878 tons, respectively) compared with that in dried firms (only 2,565 tons). In contrast, the dried processing firms used higher amounts of dried coffee beans (1,326 tons) compared with mixed processing firms (only 653 tons). Wet processing firms normally used only berry coffee, so they could only process during coffee harvest season from October to March. The value of the coffee was a little different between processing firms and depends on the quality of raw coffee and the price of local market. So far, the domestic price has been influenced by the world coffee market. Normally, coffee prices always fluctuates so that some dried

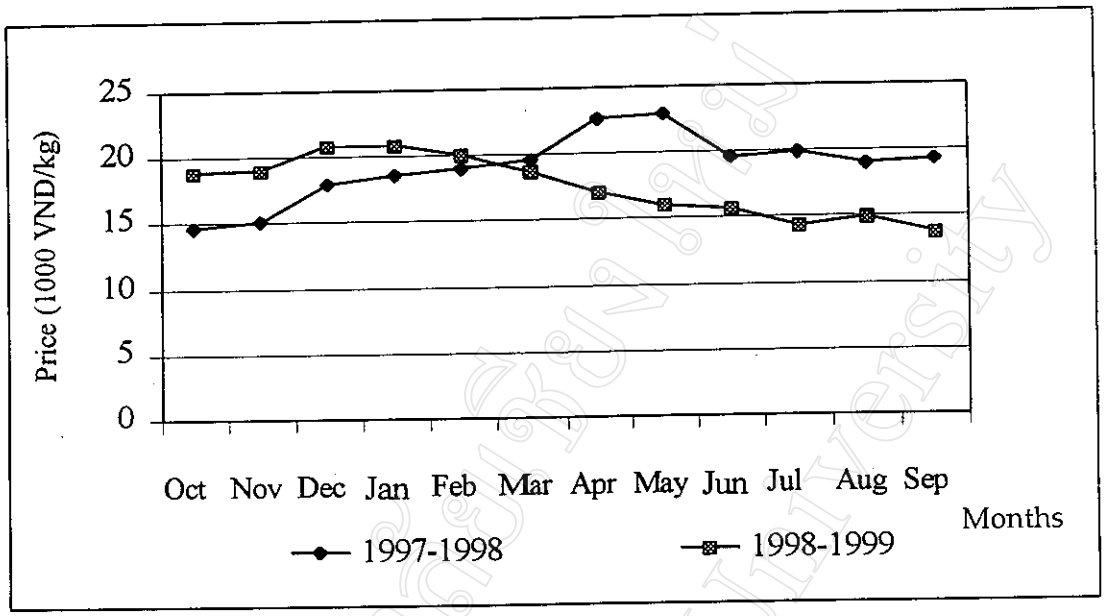
and mixed processing firm who often buy dried coffee bean every month of the year can profit if buying prices are low and selling prices are high and vise versus.

Because they lack money and store facilities, dried and mixed processing firms often store enough raw coffee for processing for two or three months. If the selling price is low they can lose their profit, but usually not so much. While wet processing firms only work for short periods they have to buy all berry coffee at harvest time. Thus, the wet processing firms can get higher profit if the world coffee price at time of selling is high. They also have high risk if the world coffee market price decline. Therefore, the economic efficiency of coffee processing firms is affected by many factors such as the technologies that they use, the plant's management skills, and the information that they rely on for their decisions on buying and selling their products. Clearly, the price of coffee beans in domestic markets has been one of the main factors that affect to the economic efficiency of coffee processing firms.

According to ITC (1996) since July 1994 the market has been extremely volatile, with price fluctuating by as much as two percent from one hour to the next. Price fluctuations of such magnitude complicate the exporters' daily business enormously and multiply their risk factors manifold. Thus, coffee prices in domestic markets are also affected by world coffee prices, which are determined by prices in the export market. Figure 5.1 is an example of buying prices of coffee beans in Daklak market 1997-1998.

The Figure 5.1 shows that the prices of coffee beans were not stable in the Daklak market. The coffee prices were very different between months and quarters of the year. The price of coffee fluctuated from 15,000 VND per kg to 22,000

VND per kg. This is because the world coffee price at this time also fluctuated from 1,000 $US to 1,600 $US per ton.



Source: Peoples committee of Daklak, 1999.

Figure 5.1: Buying prices of coffee beans in Daklak market 1997- 1998

The difficulty of wet processing firms is how can they buy enough berry coffee for processing. This depends on a lot of factors such as the scale of material input, the contracts between farmers and processing firms, and particularly the setting of coffee prices at the time of harvest. Generally, most farmers are familiar with the dried processing by sunshine, but they do not want to sell their berry coffee immediately after harvesting. Except farmers who belong to state coffee plantations, they have to sell their berry coffee to the processing plant based on signed contracts with the processing plants. These contracts are usually signed in the beginning of a calendar year. It is a simple buying-sale agreement. The contracts are signed by farmers and the planning department of processing firms. These contracts specify the quality and quantity of berry coffee and the processing

plant has the right to refuse products which do not meet the quality standard. The time of delivery is within two days notice by the plant.

Although one of the purposes of the establishment of processing plants is to add value to the local beans and improve market competitiveness, the processing plants and farms are actually two independent business operations. Thus the plant's purposes are to negotiate a contract with the farmers to minimize the risks of uncertainty in raw material supply and price fluctuations, and to reduce production costs. Farmers are willing to sign these contracts because this is an additional marketing channel for their products and they want assurance for marketing of their products as well as certainty for the prices and minimizing marketing costs. This kind of contract is usually used for supplying raw materials to wet processing firms.

5.2 Outputs structure in the firms interviewed

5.2.1 Coffee bean standard for export

ITC (1996) revealed that the liberalization process of official export quality controls and the licensing of exporters in recent years has brought major changes to the marketing systems in a number of countries with established State monopolies being replaced by private millers and exporters. Lack of experience and fierce competition for supplies at the producer level, especially when prices were rising strongly as in 1994, have at times resulted in the export of underdried and substandard coffees.

Generally, coffee quality depends on the whole production and post harvest technologies. In general, coffee quality depends on the coffee variety chosen,

natural condition (soil, climate), the maturity of coffee cherries collected, and the methods of processing. For green coffee importers, quality is evaluated according to the size of the coffee beans, their color, and amount of broken beans (see Table 4.1).

5.2.2 Outputs structure in the firms interviewed

The average quantity and quality of coffee outputs in the coffee processing firms surveyed is summarized in Table 5.2.

Table: 5.2 Average quantity and quality of coffee outputs of surveyed firms 1998

	Total	R1		R2A		R2B	
Types of firms	Q (tons)	Q (tons)	V (Mill.D)	Q (tons)	V (Mill.D)	Q (tons)	V (Mill.D)
Wet	3,442	1,056	22,629	1,887	35,726	499	7,083
Dried	1,826	498	10,404	1,016	19,689	311	4,259
Mixed	1,772	532	10,861	957	18,213	310	3,658
Average	2,138	617	12,938	1,178	22,601	343	4,704

Note: Q denotes the quantity of coffee

V denotes the value of coffee

There are three grades of coffee outputs namely R1, R2A, and A2B according to the size of coffee beans, their color, and amount of broken beans. The average amount of coffee output of processing firms was 2138 tons per year. The wet processing firms, on the average, had processed coffee outputs of 3,442 tons, which is approximately twice as much as that of dried processing firms which had 1,826 tons coffee beans per year.

Similarly, the average output value of processed coffee in wet processing firms was higher than that in dried and mixed processing firms. The average size of wet processing firms was larger than in dried and mixed ones.

Total coffee output and the proportion of outputs of the firms surveyed are shown in Table 5.3. The wet, dried and mixed processing firms produced about 32.1%, 51.1% and 16.8% of coffee beans, respectively. Similarly, the average total amount of R1, R2A, R2B samples were 28.8%, 55%, 16.2%, respectively. According to export standards, the proportion of R1 and R2A made in wet processing firms was 30.7% and 54.8%, respectively; whereas coffee made in mixed processing firms were 29.6%, 53.1%, respectively.

Table 5.3: Total output structure of coffee processing firms surveyed in the Central Highland, Vietnam, 1998

Kind of coffee	Total		R1		R2A		R2B	
Types of firms	Q (Tons)	P (%)	Q (tons)	P (%)	Q (tons)	P (%)	Q (tons)	P (%)
Total	96,463	100	27,756	28.8	53,034	55.0	15,673	16.2
Wet	30,978	32.1	9,503	30.7	16,979	54.8	4,495	14.5
Dried	49,286	51.1	13,457	27.3	27,446	55.7	8,384	17.0
Mixed	16,199	16.8	4,796	29.6	8,609	53.1	2,794	17.2

Note: Q = quantity of coffee (ton)

P = percent compared with total

Both of these proportions in these firms were higher than those in the dried processing firms, which had only 27.3% and 55.7% of R1 and R2A, respectively.

Thus, although the dried processing is popular in this area, wet processing produced higher proportions of better grade products than other firms.

5.3 Costs and returns of the coffee processing firms surveyed

5.3.1 Costs analysis

The cost structure of the coffee processing firms surveyed is summarized in Table 5.4. The data in this Table is averages for different processing groups.

Data in Table 5.4 shows that there are three main costs: raw materials, processing and marketing costs. On the average, the proportion of raw material costs is highest. It is about 96 % of the total cost of processing firms, followed by processing costs (2.78 %), and marketing costs (1.11 %).

The average cost of one processing firm was 39,106 Million VND and decreases from wet to dried and mixed processing firms. In three groups, the lowest percent of raw material in comparison with total cost was in mixed processing firms (95,48%). While this proportion in dried and wet processes were 96.8% and 95.6%, respectively. The second component in total cost is processing costs. This is highest in wet processing firm (3.54% of the total cost) and lowest in dried firms (only 2.18% of the total cost). Two main costs included in processing costs are direct labour cost and depreciation costs. Direct labour costs are highest in wet processing firms (38.67 % of the total processing cost) and lowest in dried firms (only 25.72% of the total processing cost). The depreciation cost proportion was highest in mixed processing firm (39.77% of the total processing cost) while this proportion was only of 33.14% of the total processing cost in dried firms.

Table 5.4: Average cost per firm classified by processing methods in CHL, 1998

Unit: Million VND

Items	Average		Wet		Dried		Mixed	
	V*	(%)	V	(%)	V	(%)	V	(%)
Total cost	39,106	100	63,728	100	33,412	100	31,572	100
1 Raw Materials	37,625	96.2	60,921	95.6	32,353	96.8	30,146	95.5
2 Processing costs	1,046	2.8	2,154	3.5	706	2.2	958	3.2
Electricity	86.1	8.2	190.4	8.8	64.1	9.1	47.9	5.0
Water	24.2	2.3	68.1	3.2	3.1	0.0	43.3	4.5
Instruments	72.8	6.9	119.6	5.6	76.2	10.8	15.8	1.6
Sacks	131.8	12.6	125	5.8	132.8	18.8	135.5	14.1
Direct labours	336.7	32.2	833	38.7	181.6	25.7	305.6	31.9
Managerial costs	16.3	1.5	9.1	0.4	14.4	2.04	29	3.0
Depreciation	378.5	36.2	809	37.6	234	33.2	381	39.8
3 Marketing cost	434.9	1.1	652.5	1.1	352.6	1.1	468.2	1.48
Transportation	261.8	60.2	526.1	80.6	180.5	51.2	241.5	51.6
Others costs	103.8	23.8	85.5	13.1	97.3	27.6	143.6	30.7

Note: V denotes value in Million VND (million Vietnamese Dong)

Another important cost of the coffee processing firms was marketing costs, mainly for transportation. The transportation cost was highest in wet processing firms (80.63 % of the marketing cost) and lower in dried and mixed ones (approximately of 51 %). There are two reasons for this. First, although most of wet processing firms have been built recent years, some of them have not utilized their total capacity. Wet processing firms have high raw materials costs and hence need more expenditure for processing. Second, it requires more labour, machines,

and depreciation costs. Dried processing is simpler, saves labour cost, and has less depreciation, and water costs as compared with wet processing.

5.3.2 Returns analysis

The survey results on costs and revenue of coffee processing firms using Gross Margin Analysis (GM) is shown in Table 5.5.

Table 5.5: Average costs and revenue per firm, CHL, VN, surveyed in 1998.

Unit: Million VND

Items	Average	Wet	Dried	Mid
A. Gross revenue	40,244	65,439	34,350	32,732
B. Total costs	39,037	63,687	33,337	31,489
BI. Variable costs	38,642	62,869	33,088	31,079
1. Raw Materials	37,625	60,921	32,353	30,146
2. Processing costs	1,017	1,948	736	933
Direct labours cost	336.7	833	181.6	305.6
3. Gross margin	1,602	2,570	1,261	1,653
BII. Fixed costs	395	818	248	410
C. Net return	1,207	1,752	1,013	1,243
*Net return to labor	1,544	2,585	1,195	1,549
* Gross margin to labor	1,938	3,404	1,443	1,959
*Net return to labor / revenue	3.84	3.95	3.48	4.73
* Gross margin to labor /revenue	4.8	5.2	4.2	5.98

The data in Table 5.5 indicates that the gross revenue and total costs tend to decrease from wet to mixed processing firms. They were highest in wet processing firms (65,439 million VND and 63,687 million VND, respectively) and lowest in

mixed firms (32,732 VND million and 31,489 million VND respectively). While gross margin and net returns were highest in wet processing firms and lowest in dried firms. This is because wet processing firms have larger production scales in comparison to the other firms. Despite low processing costs (only 2.18% compared with the total cost) in dried-processing firms, they appeared to have the lowest gross margin and net return (1,261 million VND and 1,013 million VND, respectively) in comparison to other firms.

In contrast, although mixed processing firms had lower gross revenue (32,732 mill. VND), they had higher gross margin (1,653 mill. VND) and net return (1,243 mill. VND) than those of dried processing firms. The data also shows that the net return to labor and gross margin to labor was highest in wet processing firms (2,585 and 3,404 mill.VND respectively) and lowest in dried one (1,195 million VND and 1143 million VND, respectively).

In relative terms of percent of gross margin and net return in comparison with gross revenue, mixed processing firms had higher economic return compared to wet and dried firms. The survey data shows that mixed-processing firms had the highest gross margin (5%) and net return (3.8%) in comparison with their gross revenues. Table 5.5 also shows that the ratios between net return to labour and gross margin to labour with revenue were highest in mixed processing firms and lowest in dried firms. This is because wet and mixed processing firms pay higher labour costs than dried firms. Since most of the labourers who are working in these firms are state workers. Thus, these firms have to pay higher salaries to their workers. Dried processing firms normally use a higher proportion of temporary laboures so that wages are lower. Table 5.6 shows the details of comparative cost-benefit parameters.

B. ECONOMICS EFFICIENT ANALYSIS

5.4 Profitability of coffee processing firms

Table: 5.6 Analysis of Costs and Profit per ton of processed coffee, In the CHL, VN, 1998

Unit: million VND

Items	Average	Wet	Dried	Mixed
1 Gross Revenue	18.8	19.01	18.82	18.47
2 Total costs	17.443	18.503	18.267	17.770
- Material cost	17.266	18.265	18.131	17.539
- Processing costs	0.291	0.388	0.251	0.309
3 Gross margin	0.716	0.747	0.691	0.933
- Fixed costs	0.176	0.238	0.136	0.231
- Labor cost	0.16	0.24	0.11	0.19
4 Net return	0.54	0.51	0.56	0.70
5 Gross margin to labor	0.866	0.989	0.791	1.105
6 Net return to labor	0.690	0.751	0.655	0.874
7 Net return / total cost (%)	3.09	2.75	3.04	3.94

Table 5.6 shows that although the average revenue per ton of processed coffee is highest in wet processing (19.01 million VND per ton) and lowest in mixed processing firms (18.47 million VND per ton). But the net return per ton of processed coffee was highest in mixed processing firms (0.70 million VND per ton) and lowest (0.51 million VND per ton) in wet firms. This is probably associated with the fact that the total cost per ton of processed coffee was highest in wet processing firms (18.503 million VND per ton) and lowest in mixed processing firms (17.77 million VND per ton). Mixed processing firm had lower

total cost because the mixed processing firms had lower raw material cost, which is main part of total costs, when comparison with other groups. Wet processing firms had high total cost because of their higher depreciation and labour costs (0.24 million VND per ton) than those of other firms while dried processing firms had labor cost of 0.11 million VND per ton. The ratio between net return and total costs per ton of processed coffee was highest in mixed processing firms (3.94%), while in the case of wet processing firms, this ratio was only of 2.75%.

In terms of gross margin to labor and net return to labor per ton, there was little difference among the firms. The gross margin to labor and net returns to labor per ton in mixed processing firms was highest (1.105 and 0.874 mill. VND per ton of processed coffee, respectively). While comparing these ratios between wet and dried processing firms, the data show that wet processing firms had higher gross margin to labor and net return to labour (0.989 and 0.751 million VND) than in dried processing firms (0.76 and 0.63 million VND). This is due to more labor and higher labor costs per ton of processed coffee in wet processing firms as compared to the case in dried processing firms. Thus, the net return, gross margin to labor and net returns to labor per ton in mixed processing firms were highest. There was not much difference between wet and dried processing firms in terms of economic return. This is due to the fact that most wet processing plants have been rebuilt in recent years or some of them started processing in 1998 and, therefore, these plants had not run in full capacity. Second, wet processing plants normally work during one third of year while dried processing plants work regularly almost all year. Therefore, the processing costs per ton were lower in the later case. Third, the prices between two products from wet and dried processing firms were not much different in the market. This is because most all of coffee in the Central Highland region was robusta coffee. Therefore, the different price between these products is not so large in comparison with arabica. However, mixed processing firms take

advantages of higher prices by using wet processing and longer processing periods by using dried processing so that they can lower the total cost per ton of processed coffee.

5.5 Nonparametric Models

5.5.1 Descriptive statistics of the variables

The data in Table 5.7 shows that there was high variation in overhead, other material and labor costs. Their coefficients of variation (CV) were about 55.5%-66.6%. The CV for raw material costs, revenue, and marketing cost were high around 50.2 % to 51.6 %. The lowest coefficients of variation were found for cost of depreciation, water, and energy variables (27.2%- 30%).

Table 5.7 Descriptive statistics of the Variables included in the model for the wet coffee processing firms, CHL, Vietnam, 1998

Unit: Million VND

Variables	Mean	Std. Dev	CV	Min	Max
Revenue	65,439.0	33,246.0	50.8	11,153.0	102,837.0
Raw materials	60,921.0	31,416.0	51.6	9,258.0	95,557.0
Energy	190.4	68.7	36.0	55.0	250.0
Water	68.1	19.0	30.0	25.0	92.0
Other materials	244.6	151.1	61.8	22.0	381.0
Marketing	567.0	284.4	50.2	113.0	955.0
Labour	833.0	462.5	55.5	121.0	1,320.0
Depreciation	808.0	219.7	27.2	480.0	1,189.0
Overhead	53.7	35.8	66.6	7.0	130.0

The wet processing firms can divided into two sub-groups. The first group is included the firms were upgrade from the old dried processing firms. These firms were normally small. The second group includes some new wet processing firms with a larger scale. These firms have been established in the 1990's with new

processing machines, some has just operated since 1998. Therefore, high variations in overhead, labor, and material costs could be expected. Another reason that explains such high CV on inputcosts of this group was a wide range of their scales of operation.

There was very high variation in marketing, depreciation, and energy expenditures among dried processing firms (Table 5.8). The coefficients of variation (CV) were highest in marketing cost (117.4%). This because there were 27dried processing firms, of which some were very small. These firms often buy coffee beans and reproducing, primary classifying then sells at the firm gate. Therefore, they have no marketing cost or pay with small amounts of money. Big firms spend more money for marketing services and the main part their marketing expenditure was transportation costs. Big firms often pay transportation cost to transfer their products from Daklak to Ho Chi Minh port. The transportation cost per tons was around 150,000-170,000 VND. Table 5.8 also shows that the CV had high variation for other expenditures. This is because of the large differences in the scale of dried processing firms.

Table 5.8 Descriptive statistics of the variables in 27 dried processing firms, CHL, Vietnam, 1998

Unit: Million VND

Variables	Mean	Std. Dev	CV	Min	Max
Revenue	34,682.0	24,229.0	70.1	3,871.0	98,447.0
Raw materials	32,353.0	23,378.0	72.3	3,300.0	92,620.0
Energy	65.4	51.8	79.2	2.0	187.0
Water	0.0	0.0	M	0.0	0.0
Other materials	209.1	138.1	66.0	15.0	400.0
Marketing	255.3	299.9	117.4	2.0	1,185.0
Labour	181.6	137.1	75.5	32.0	508.0
Depreciation	234.3	195.7	83.5	18.0	736.0
Overhead	36.9	29.6	76.5	5.5	115.0

Note: M = absolutely high value

Table 5.9 indicates that there are not much differences in the CV of mixed processing firms in comparison to wet processing firms. The CV variable was highest in water expenditure (74.4%) and lowest in labour cost (22.2%). This is because there is not much difference in labour used, as they were less variation size. Inversely, the costs paid for one m^3 of water are different depending on the location of these firms. Another reason depends on the technological level and their equipment so the amount of water used for processing one ton of coffee is different between the firms.

Table 5.9 Descriptive statistics of the variables in mixed coffee processing firms, CHL, Vietnam, 1998

Unit: Million VND

Variables	Mean	Std. Dev	CV	Min	Max
Revenue	32,725	18,103	55.3	10,793	64,051
Raw materials	30,146	17,738	58.8	9,100	61,260
Energy	47,889	23.9	49.8	19.0	95.0
Water	43.5	32.3	74.4	10.3	105.0
Other materials	151.3	74.9	49.5	54.0	298.0
Marketing	324.7	109.9	33.8	175.0	540.0
Labour	305.6	67.8	22.2	180.0	390.0
Depreciation	381.0	228.6	60.0	111.0	774.0
Overhead	89.6	27.3	30.4	58.0	135.0

5.5.2 Programming models

Two linear programming models for each group of the coffee processing firms were run to solve the problem (2) (unconstraint) and (3) (constraint) for the bounded-technology condition. These two models were also run again for all 45 firms to allow the analysis of unbounded-technology condition. Basically, the programming structures and format were the same. The objective functions were the same for these two models describing the gross revenue (revenue of the three grades of coffee subtracted by the six expenditure categories). There were 12

constraints for the first models (see for example, Figure 5.2). These constrains were classified into 3 groups. The first group of constraints represented a revenue condition (constraint 1-3, Figure 5.2). The second group demonstrated cost condition (constraint 4-11, in Figure 5.2). And the last group expressed the intensity variable condition. Notably, number of *Zk* was as many as the total firms in the group.

MAX R1 + R2 + R3 - CV1 - CV2 - CV3 - CV4 - CV5 - CV6

SUBJECT TO

1) 33770Z1 + 29304Z2 + 37716Z3 + 3269Z4 + 7749Z5 + 13499Z6 + 26906Z7 + 24087Z8 + 27363Z9 - R1 >= 0

2) 46835Z1 + 42732Z2 + 57321Z3 + 7451Z4 + 12065Z5 + 17917Z6 + 45334Z7 + 43586Z8 + 48298Z9 - R2 >= 0

3) 7196Z1 + 7501Z2 + 7800Z3 + 433Z4 + 2256Z5 + 3750Z6 + 11385Z7 + 12105Z8 + 11326Z9 - R3 >= 0

4) 80875Z1 + 74361Z2 + 95557Z3 + 9258Z4 + 20214Z5 + 32234Z6 + 79150Z7 + 74416Z8 + 82224Z9 - CV1 <= 0

5) 230Z1 + 210Z2 + 250Z3 + 55Z4 + 105Z5 + 165Z6 + 239Z7 + 215Z8 + 245Z9 - CV2 <= 0

6) 73Z1 + 69Z2 + 92Z3 + 25Z4 + 55Z5 + 76Z6 + 73Z7 + 68Z8 + 82Z9 - CV3 <= 0

7) 325Z1 + 280Z2 + 381Z3 + 22Z4 + 47Z5 + 75Z6 + 366Z7 + 330Z8 + 375Z9 - CV4 <= 0

8) 718Z1 + 680Z2 + 955Z3 + 113Z4 + 205Z5 + 322Z6 + 687Z7 + 650Z8 + 773Z9 - CV5 <= 0

9) 1110Z1 + 980Z2 + 1320Z3 + 121Z4 + 225Z5 + 350Z6 + 1134Z7 + 1112Z8 + 1145Z9 - CV6 <= 0

10) 943Z1 + 964Z2 + 1189Z3 + 480Z4 + 590Z5 + 910Z6 + 690Z7 + 675Z8 + 840Z9 <= C_{f1}^{k}

11) 75Z1 + 62Z2 + 130Z3 + 7Z4 + 21Z5 + 65Z6 + 40Z7 + 38Z8 + 45Z9 <= C_{f2}^{k}

12) Z1 + Z2 + Z3 + Z4 + Z5 + Z6 + Z7 + Z8 + Z9 = 1

END

Where

R1, R2, and R3 is revenue of three different grades of coffee outputs z1…zk is k firm.

CV1... CV6 are raw material, energy, water, other material, marketing, and labour costs.

C_{f1}^{k} is the observed value of the depreciation cost of coffee processing firm *k*. It varies from firm to firm depending on which firm is being analyzed.

C_{f2}^{k} is the observed value of the overhead costs of coffee processing firm firm *k*. It varies from firm to firm depending on which firm is being analyzed

Figure 5.2 The programming model for unconstraint wet processing firms.

The second programming model was the same as that of the first one excepting that the fourth group of constraint was added (constraint 13-14) in Figure 5.3). These added constraints demonstrated that firm was facing two types of expenditure constraint- the cost of raw material (E_1^k) and other variable costs (E_2^k)

MAX R1 + R2 + R3 - CV1 - CV2 - CV3 - CV4 - CV5 - CV6

SUBJECT TO

1) 33770Z1 + 29304Z2 + 37716Z3 + 3269Z4 + 7749Z5 + 13499Z6 + 26906Z7 + 24087Z8 + 27363Z9 - R1 >= 0

2) 46835Z1 + 42732Z2 + 57321Z3 + 7451Z4 + 12065Z5 + 17917Z6 + 45334Z7 + 43586Z8 + 48298Z9 - R2 >= 0

3) 7196Z1 + 7501Z2 + 7800Z3 + 433Z4 + 2256Z5 + 3750Z6 + 11385Z7 + 12105Z8 + 11326Z9 - R3 >= 0

4) 80875Z1 + 74361Z2 + 95557Z3 + 9258Z4 + 20214Z5 + 32234Z6 + 79150Z7 + 74416Z8 + 82224Z9 - CV1 <= 0

5) 230Z1 + 210Z2 + 250Z3 + 55Z4 + 105Z5 + 165Z6 + 239Z7 + 215Z8 + 245Z9 - CV2 <= 0

6) 73Z1 + 69Z2 + 92Z3 + 25Z4 + 55Z5 + 76Z6 + 73Z7 + 68Z8 + 82Z9 - CV3 <= 0

7) 325Z1 + 280Z2 + 381Z3 + 22Z4 + 47Z5 + 75Z6 + 366Z7 + 330Z8 + 375Z9 - CV4 <= 0

8) 718Z1 + 680Z2 + 955Z3 + 113Z4 + 205Z5 + 322Z6 + 687Z7 + 650Z8 + 773Z9 - CV5 <= 0

9) 1110Z1 + 980Z2 + 1320Z3 + 121Z4 + 225Z5 + 350Z6 + 1134Z7 + 1112Z8 + 1145Z9 - CV6 <= 0

10) 943Z1 + 964Z2 + 1189Z3 + 480Z4 + 590Z5 + 910Z6 + 690Z7 + 675Z8 + 840Z9 <= C_{f1}^k

11) 75Z1 + 62Z2 + 130Z3 + 7Z4 + 21Z5 + 65Z6 + 40Z7 + 38Z8 + 45Z9 <= C_{f2}^k

12) Z1 + Z2 + Z3 + Z4 + Z5 + Z6 + Z7 + Z8 + Z9 = 1

13) CV1 <= E_1^k

14) CV2 + CV3 + CV4 + CV5 + CV6 <= E_2^k

END

Where E_1^k is the observed value of the raw materials cost of coffee processing firm *k*. It is varies from firm to firm depending on which firm is being analyzed.

E_2^k is the observed total value of other variable costs of coffee processing firm *k* (except raw coffee input costs). It is varies from firm to firm depending on which firm is being analyzed.

Figure 5.3 the linear programming models for constrained wet processing firms.

Finally, the two programming models for unbounded-technology condition were the same as those mentioned above. The only exception was that the include all 45 firms to have 45 Zk (Z1, Z2, Z3,..., Z45)

The linear programming model used for dried and mixed processing groups under bounded technology condition and those unbounded-technology conditions are presented in Appendix.

5.6 Empirical results and discussion

5.6.1 Index of economic efficiency of coffee processing firms under bounded-technology condition

To get the efficiency results of different coffee processing firms from the observed data within the group, short-run expenditure constrained profit and short-run expenditure unconstrained profit were calculated for all firms. The results of financial efficiency, actual efficiency, and overall efficiency were calculated for each group. They are presented in Table 5.10

Table 5.10 shows that three of the nine wet processing firms faced binding expenditure constraints *i.e.* F_b^k from equation 4 was less than unity. These firms loosed an average of about 22 % of unconstraint profit. There were no constraint firms which have an actual efficient, financial efficient or overall efficient equal unity in expenditure constraint group. The data also shows that three out of nine firms are actual efficient while six firms are financially efficient. The number of overall efficiency firms in this group is three. This indicates that only some actual efficient firms are also financially efficient (that is they are overall efficient), but financially efficient firms are not necessarily actually efficient. With given fixed inputs, to achieve overall efficient, financial and actual efficiency must be a priori allow firms to buy desired levels of variable inputs.

Table 5.10 Index of efficiency of coffee processing firms and number of efficient firms classified by firm group

	Wet		Dried		Mixed	
	E	EU	E	EU	E	EU
Measure (number of firm)	3	6	16	11	5	4
Actual efficiency (A_b^k)	0.589	0.834	0.609	0.775	0.920	0.900
Number of actually efficient firms ($A_b^k = 1$)	0	3	3	5	0	0
Financial efficiency (F_b^k)	0.775	1	0.711	1	0.919	1
Number of financially efficient firms ($F_b^k = 1$)	0	6	0	11	0	4
Overall efficiency (O_b^k)	0.452	0.834	0.491	0.775	0.844	0.836
Number of overall efficient firms ($O_b^k = 1$)	0	3	0	5	0	0

Notes: E denotes expenditure constraint firms
EU denotes expenditure unconstraint firms

Similarly, the mixed processing group has five of the nine firms with expenditure constraint problems (F_b^k less than unity). These firms lost their profit on an average about 8 % in comparison with unconstraint profit. Non of the nine-mixed processing firms is actually efficient and only four firms are financially efficient. No firm in this group was overall efficient (O_b^k=1) But on the average, the mixed processing firms have high F_b^k, O_b^k (0.919 and 0.844, respectively). This means that under technological bounded conditions, though more than 55% firms in this group were binding by expenditure constraint (not so serious because F_b^k greater than 0.9) but most of them operated at high efficiency level (under existing condition).

Results for dried processing firms were slightly different from other groups. The data shows that sixteen of the twenty-seven dried processing firms faced biding expenditure constraints. The average profit loss for these firms was 29% of the unconstrained profits. The number of actually efficient and overall efficient firms is the same with each (5 firms). This group had three firms which

were actually efficiency firms ($A_b^k = 1$) but not financial efficient. This implies that under observed fixed inputs and the observed level of expenditure, these firms were operating with high efficiency. This is because the deviation of A_b^k from the unit value can be interpreted as a measure of profit loss by firm k as the result of actual inefficiency evaluated at the actual expenditure level under bounded-technology.

5.6.2 Comparing the rates of observed variable expenditure to optimal expenditure of different groups under bounded-technology condition

This study further investigated the optimal expenditure usage by comparing the observed variable expenditure used of constrained and unconstrained firms with the optimal variable expenditure used of these groups. For a single expenditure category, optimal expenditure under a binding constraint can not be greater than the optimal expenditure under unconstraint. But in the case of multiple expenditure categories, some categories could be expended more or lower the observed one. Thus, examining the optimal use of variable expenditure at different levels should yield insight into the underlying technology. To satisfy this objective, first the expenditure constraint firms and unconstraint firms were selected out. Then the ratio of observed variable expenditure with and without expenditure constraint was calculated. The results of this are illustrated in Tables: 5.11, 5.12, and 5.13 as:

Table 5.11 shows that the actual variable expenditure used by wet constrained firms are not much lower than optimal variable expenditure. There are some variable expenditure was higher than optimal variable expenditure such as: water (55.6%), energy (27.9%). Inversely, some were lower when compared with the optimal expenditure such as: other material (-22.4%), labour (-11.4%). This suggested that the wet constrained firms were not utilized their variable inputs efficiency, because some variable expenditures were much overuse, and some were underused. By doing so they could not obtain the optimal profit. But for wet unconstrained firms all of observed variable expenditure were slightly higher than the optimal ones (around 6.6 %), but the CV of these variable categories are very

high (more than 100) especially, with labour cost the CV reached to 238. This can be explained that some wet unconstrained processing firms spent unreasonable. However, on the average they were only a bit deviation from the optimal categories. Thus, the wet unconstrained group performed better than wet constrained group.

Table 5.11: Percentage of observed variable expenditure and optimal variable expenditure of wet for constrained and unconstrained firms.

	Wet constrained firms		Wet unconstrained firms	
Expenditure categories	Average (%)	CV	Average (%)	CV
Cv1 (raw material)	3.3	19	5.5	133
Cv2 (energy)	27.9	92	5.3	112
Cv3 (water)	55.6	84	8.7	130
Cv4 (other materials)	-22.4	70	7	113
Cv5 (marketing)	5.5	42	9.1	146
Cv6 (labour)	-11.4	70	4	238
Overall	9.8	289	6.6	30

Table 5.12 shows the actual variable expenditure by dried constrained firms is similar with wet processing group. Some variable expenditure categories were higher than optimal ones such as: marketing (47.2%), other material (27.9%), some were lower when compared with the optimal solutions such as: energy (-12.7%), labour (-11.2%). On the average this group had only overuse 6.5 % in comparison with the optimal level. In general, with the expenditure constraint, the dried constrained firms could increased their profit if they spent reasonable by saving money from marketing and other material and spending more on energy and labour. Most all of actual variable expenditure of the dried unconstrained were higher than the optimal ones (18.7%). Especially, the expenditure on marketing was very high (overuse 49.7%). Because this group often by raw materials input during the year and they had to pay the commission fees for the agents and transportation costs. It is very difficult to manage this expenditure because of

fluctuation in dried raw coffee prices. The CV of some variables in this group are very high (more than 200) especially, the CV of energy cost reached 529. This can be explained that some dried unconstrained processing firms spent unreasonable and there was a large gap between the operation scale of dried processing firms. In general, the dried constrained group performed better than dried unconstrained ones.

Table 5.12 Percentage of observed variable expenditure to optimal variable expenditure of the constrained and unconstrained dried groups.

	Dried constrained firms		Dried unconstrained firms	
Expenditure categories	Average (%)	CV	Average (%)	CV
Cv1	2.5	243	8.3	173
Cv2	-12.7	243	-3.5	529
Cv3	0	M	0	M
Cv4	7.2	316	5.4	120
Cv5	47.2	165	49.7	165
Cv6	-11.2	262	20.3	213
Overall	6.5	434	18.7	122

Data from table 5.13 shows that there was a different between proportion of variable expenditure used by mixed constraint and unconstraint firms. The mixed unconstrained firms were over-expenditure by 7.6 % of optimal expenditure. But the CV of this group was considerably high (more than 200). On the contrary, the mixed constrained firms were underused by3.6 % of optimal expenditure. Some variable expenditure was spent lower than necessary levels such as water (23.3 %), other material (15.9%), and energy (6.7%). In general the mixed constrained group lost their profit due to lack of good allocating variable expenditures. On the other hand, profit lost of the mixed unconstrained group was due to expenditure categories.

The CV of some variables in this group is very high (more than 200) especially, with raw material the CV reached to 301. This can be explained that some mixed constrained processing firms had limited working capital. This is fact that when using wet processing method, the processing firms have to solve the raw material input supply, so they have to have enough money for buying berry coffee in short period. In general, the mixed unconstrained group performed better than mixed constrained ones.

Table 5.13 percent of actual variable expenditures to optimal variable expenditures of the mixed constrained and unconstrained groups.

	Mixed constrained firms		Mixed unconstrained firms	
Expenditure categories	Average (%)	CV	Average (%)	CV
Cv1	4.5	147	6.5	242
Cv2	-6.7	301	13.3	191
Cv3	-23.3	197	11.3	223
Cv4	-15.9	209	6.1	296
Cv5	9.7	117	7.4	225
Cv6	9.9	97	1.1	379
Overall	-3.6	384	7.6	56

5.6.3 The economic efficiency of coffee processing firms under unbounded-technology condition

In this section, the solutions from running the programming model for unbounded-technology condition were discussed. The economic efficiency of coffee processing under such condition was compared. By comparing three criteria F^k, A^k,O^k and the proportion of each subgroup that had $F^k = 1$ or $A^k = 1$ or $O^k = 1$ of each wet, dried, and mixed group we can see the different efficiency between groups. The results are summarized in Table 5.14

Table 5.14 shows that when they were not constraint by technology all of three processing groups also faced binding expenditure constraints. The proportion of unconstraint firms in the wet, dried and mixed groups were 66.7%, 44.4%, and non, respectively. This proportion is highest in wet processing groups and lowest in mixed ones.

Table 5.14 Index of economic efficiency of coffee processing firms and proportion of efficient firm classified by processing group

Criteria	Wet	Dried	Mixed
Actual efficiency (A^k)	0.743	0.662	0.708
Percent of actually efficient firms (A^k=1) (%)	33.3	22.2	0
Financial efficiency (F^k)	0.929	0.837	0.658
Percent of financially efficient firms (F^k=1) (%)	66.7	44.4	0
Overall efficiency (O^k)	0.701	0.560	0.456
Percent of overall efficient firms (O^k=1)	22.2	18.5	0

The wet processing group had the highest proportion of actually efficient firms (33.3%), financially efficient firms (66.7%) and over all efficient firms (22%). While these proportions in dried ones were 22.2%, 44.4%, and 18.5%, respectively. Non of the mixed processing firms was economically efficient.

The profit losses due to expenditure constraint under unbounded-technology condition were 22% in the wet, 29.3% in the dried and 34.2% in the mixed processing firms. These levels of profit losses when compared to those in the same group under bounded-technology condition demonstrated that only the profit loss of the mixed was substantially increased. This is because the mixed constrained firms were tied with a small budget. They might not only have sufficient budget for buying more variable inputs but also for investing in new and

better technology. They could also imply that the mixed group faced seriously budget constraint.

A comparison among actual efficiency index showed that the wet group was highest while it lowest in the dried one. This implies that on the average the wet group was best in managing budget (resources). On the contrary, the dried was the worst on this matter. It was mainly due to the fact that the wet processing firms were largest in the scale of operation while the dried one was smallest. With larger scale usually employ better management style. Undoubtedly, the dried group was in the opposite direction.

The results also show that the criteria of all three groups were different. These efficient are highest in wet processing firms and lowest in mixed ones. Table 5.14 shows that the overall efficient index O^k in mixed processing firms were 0.923, 0.560, and 0.456. Therefore, we can conclude that under unbounded-technology condition the wet processing firms had highest efficiency, followed by the dried and mixed ones.

5.7 Summary

In summary, when facing with binding expenditure constraints under bounded expenditure-technological condition, the wet, dried and mixed constrained groups was lost of 22%, 29% and 8 % of their unconstraint profit.

The average profit losses from expenditure constrained firm under unbounded-technology condition were 21% in the wet, 29.3% in the dried and 34.2% in the mixed one. The wet group was the best in managing resources. Finally, It was concluded that the wet processing firm operated at the highest overall efficiency under unbounded-technology condition followed by the dried and the mixed ones.

In general, mixed processing firms operated at the highest efficiency level, followed are wet and the dried processing firms.