CHAPTER 5

IMPACTS OF INPUT USE, TECHNOLOGICAL AND EFFICIENCY CHANGE ON AGRICULTURAL PRODUCTION AND POLICY IMPLICATION

5.1 Introduction

Considering only the growth rates of production input listed in Chapter 2, intuitively, the following conclusion might be drawn: agricultural growth in northern Thailand, was mainly due to the increase in land productivity associated with large increase in tractors and irrigated land than labor. While these conclusions suggest some hypotheses on the pattern of evolution of agricultural performance for the past seventeen years, growth rates of input use cannot tell us about their relative contribution to growth without a framework to evaluate their productivity and to weigh their relative importance in the production process. The parameters of the production functions estimated in this study (as shown in Chapter 4) can therefore be used, to analyze the structure of factor contribution to growth of each zone. While such analysis is based on a mixture of information of different origins and statistical significance, it takes into account productivity changes within a consistent theoretical framework and is likely, therefore, to present a more accurate picture of the distribution of growth among its three basic sources: (i) input or factor increases, (ii) technical change, and (iii) efficiency change or individual provincial performance in agricultural production.

To separate the effects on production growth (in terms of average annual growth rate) of an increase in inputs, technological progress and technical efficiency change, the following approach is employed. Using translog (restricted) production functional form, the production function (6) can be reexpressed as:

$$\ln Y(t) = a_0 + \sum_i a_i \ln x_i(t) + \sum_i a_{it}[\ln x_i(t)] \cdot t + a_t t + a_{tt}t^2 + \ln[e^{u(t)}] + v(t) \qquad (12)$$

Let $\ln A_o(t) = a_o + a_t t + a_{tt}t^2 + v(t)$, $a_i(t) = a_i + a_{it}t$, and $E(t) = e^{u(t)}$, then (12) can be shown as:

$$\ln Y(t) = \ln A_0(t) + \sum_i a_i(t)\ln x_i(t) + \ln E(t) \qquad (13)$$

Taking the first derivative of (13) with respect to time t, the growth rate of total production can be accounted as:

$$\partial \ln Y(t) / \partial t = \partial \ln A_0(t) / \partial t + \sum_i a_i(t) \cdot \partial \ln x_i(t) / \partial t$$
$$+ \sum_i \ln x_i(t) \cdot \partial a_i(t) / \partial t + \partial \ln E(t) / \partial t \qquad (14)$$

The first term on the right hand side of (14) measures neutral technological change. The second term captures the effect of input change on production growth; it is the sum of growth rates in inputs weighted by the relevant production elasticity. The third term measures the effects of biased technological change on production growth; if it is positive, output has increased through biased technological change (using abundant resources to substitute for scarce resources). The last term reflects the effect of efficiency improvement on production growth.

5.2. Detailed Results of the Analysis by Region and Zone

Using Equation (14), the accounting for the sources of total production growth is presented in Table 5.1 and Figure 5.1. In Table 5.1, the "biased technological (factor specific) change" and "total input growth" categories, analyze the importance of the

change in input factor shares, for the provinces in the northern region as a whole, vis-a-vis the level of input use, which is the only element involved in the output change whose origin is traceable factor by factor.

The "total productivity growth" category, including "efficiency change" and " technological change" two sub-categories, was obtained by subtract the "total input growth" from "total production growth" registered by every zone and regional levels.

Similarly, neutral and biased technological change are considered as total technological change in the accounting and obtained by subtracting the "efficiency change" from "total productivity growth".

The "neutral technological change" was treated as the residual since there is no way to calculate the real neutral technological change even though the time trend (T) was used as a proxy. Mathematically, both sides of equation (14) are definitely identical, however, in practice, the term $v(t)$ embodied in $\ln A_o(t)$ is unobservable. Due to this reason, the accuracy or reliability of the neutral technological change effect on production should be stated more clearly. In this study, one important input factor, i.e., fertilizer was excluded. Consider the chemical fertilizer quantities used in recent years and the experiences of farmers to use them, the contribution of fertilizer, more or less, probably exist. Thus, with the omitting of other factors, the effect of neutral technological change might be overstated. In other word, the statistics of technological change effect on production presented in Table 5.1 can be regarded as it's top limit.

From Table 5.1, it can be seen that the differences in sources of production growth among zones are substantial because of differences in the resource endowments and total factor productivity growth. Growth in total agricultural production varied from 1.18% in zone B to 9.06% in zone C. The total contribution of total input growth to production growth varies from 28.1% in zone C to 103.2% in zone A. The differences in labor and tractor input explain most of the differences in total input growth. The differences in land input growth are small.

Table 5.1 Accounting for Growth of Total Agricultural Production in Terms of Annual Growth Rate, 1975-1991

Zone	A	B	C	D	Regional
Total Production Growth	2.20	1.18	9.06	3.13	3.27
	(100)	(100)	(100)	(100)	(100)
Total Input Growth	2.27	1.01	2.55	1.84	1.77
	(103.2)	(85.6)	(28.1)	(58.8)	(54.1)
Labor	1.20	.15	1.12	.31	.74
	(54.5)	(12.7)	(12.4)	(9.9)	(22.6)
Land	0.12	.08	.14	.03	.08
	(5.5)	(6.8)	(1.5)	(1.0)	(2.4)
Tractors	.83	.56	.80	.53	.66
	(37.6)	(47.5)	(8.8)	(16.9)	(20.2)
Irrigation	.12	.22	.49	.97	.29
	(5.5)	(18.6)	(5.4)	(31.0)	(8.9)
Total Productivity Growth	.07	.17	6.25	1.29	1.50
	(-3.2)	(14.4)	(71.9)	(41.2)	(45.9)
Efficiency Change	-.53	-.23	2.49	-.27	.10
	(-24.1)	(-19.5)	(27.5)	(-8.6)	(3.1)
Technological Change	.46	.40	4.02	1.56	1.40
	(20.9)	(33.9)	(44.4)	(49.8)	(42.8)
Neutral Tech. Change	.29	.24	3.86	1.39	1.24
	(13.3)	(20.4)	(42.6)	(44.3)	(37.8)
Biased Tech. Change	.17	.16	.16	.17	.16
	(7.7)	(13.5)	(1.8)	(5.5)	(5.0)
--Labor	-.077	-.074	-.071	-.071	-.073
	(-3.50)	(-6.23)	(-.78)	(-2.26)	(-2.24)
--Land	.221	.216	.221	.232	.221
	(10.05)	(18.31)	(2.44)	(7.41)	(6.67)
--Tractors	-.008	-.011	-.012	-.011	-.011
	(-.38)	(-9.5)	(-.13)	(-.36)	(-.33)
--Irrigation	.032	.028	.027	.024	.028
	(1.43)	(2.37)	(.03)	(.76)	(.87)

Note: Figures in parenthesis are percentage.
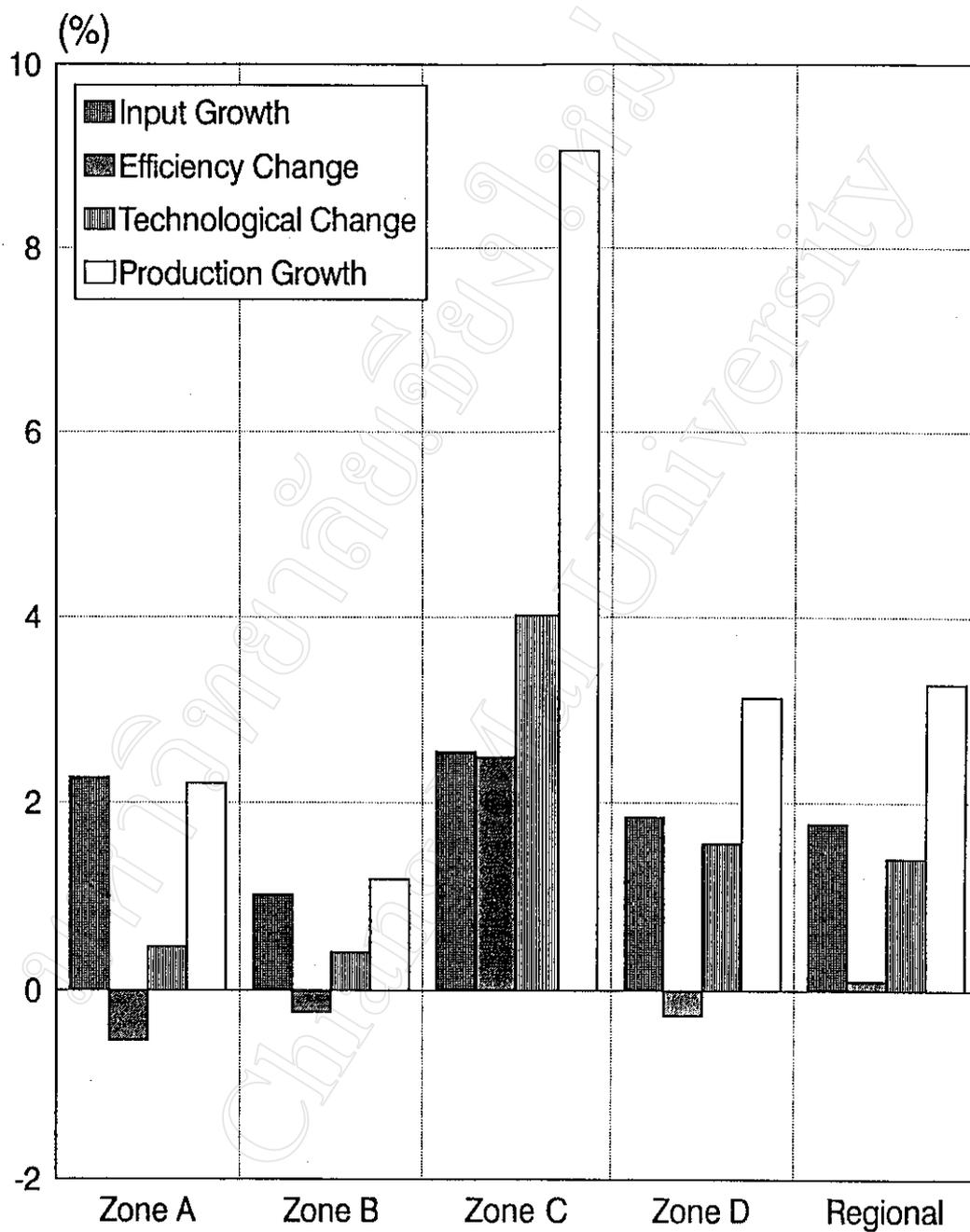
Source: Computed using Equation (14).

Figure 5.1 Sources of total production growth (in terms of annual growth rate) in northern region of Thailand, 1975-1991.

Source: Drawn from the data in Table 5.1.

The differences of the effects of technical efficiency change on production growth explain the largest share of the differences in total production growth, ranging from -24.1% in zone A to 27.5% in zone C. The contribution of technological change to production growth also has varied substantially among zones.

Before entering into the discussion of zone-by-zone performance, we can summarize the changes detected in the overall pattern of growth as follows:

First, for the northern region of Thailand as a whole, total production growth rate was 3.27% per year from 1975 to 1991; 54.1% of the growth is explained by increased use of total input and 45.9% by growth in total factor productivity.

Second, only about 6.7% of productivity change is attributed to efficiency improvement and about 93.3%, to technological change.

Third, regardless of the omitted factors, biased technological change accounted for about 11.4% of the total technological change; neutral technological change accounted about the rest 88.6%.

These results seem therefore to suggest that growth in agricultural production in the past 17 years in northern Thailand has largely occurred as a consequence of an increased application of inputs and chiefly labor, as well as modern inputs -- machinery and irrigation. Once the modern inputs are taken into account, in other words, there appears to be no autonomous increase in technical efficiency, but the total technological effects on agricultural production are essential especially the effect accelerated by neutral technological change.

5.3 The Determinants of Zone Performance

5.3.1 The Effect of Total Input Growth

The total input growth category shown in Table 5.1 , in general, portrayed the outline that all inputs in the four zones were increased during 1975 - 1991. However,

the extent to which it contributed to total production growth is rather different. On the one hand, the annual average increase rate of factors differed from each other, thus the value obtained from elasticity weighted increase rate are different. On the other hand, even the listed figures in different zones are similar, since the total production growth registered in different zones are different, the relative contribution also are different. For example, the labor contributions in the zones A and C, the value are 1.20 and 1.12 respectively, but the contribution shares to their total production are 54.5% and 12.4% respectively.

Zone A, is the unique zone of the four whose total input effect outweighed the total production growth by 3.2 percent. The effect due to labor increase accounted for more than half and labor and tractor both accounted 92.1% of their contribution to total production growth. In contrary, land and irrigation only counted a moderate share about 5.5% respectively. In zone B, tractor increase, with contribution share 47.5% to total production growth, explained the largest part about 55.5% of total input effect. The effect of irrigation increase was almost three times of the land increase effect on total production growth. Zone C is another unique case whose total input growth effects only accounted for 28.1% of that to the total production growth. In zone D, with total input use contribution 58.8% to total production growth, both labor and land contribution shares 9.9% and 1.0% were the smallest, but irrigation contribution share 31% was the largest of the four zones.

To summarize, in terms of total input growth, the pattern of growth in zone A was mainly based on the increase of labor input and accompanied by tractor increase, and in zone B, the increase of tractor and accompanied by irrigation increase; in zone C, increase in labor input and tractors; in zone D, irrigation increase accompanied by tractor increase. Land augmenting process can be seen in zone A and zone B, but in a small amount. Land use in zone C and zone D were in a general stationary situation.

5.3.2 Total Productivity Growth

Total productivity growth showed large disparities among zones. The growth of region was satisfactory, but the productivity in zone A is extremely low in the four zones. The following step will analyze the components of total productivity growth.

Efficiency Change: The efficiency has been discussed in Chapter 4. Here the relative change share, in terms of annual change rate, are displayed in relation to their total production growth in zone and regional levels. From 1975 to 1991, in the zone A, zone B and zone D, the reverse effects on total production growth were observed, which were about 24.1%, 19.5%, and 8.6% respectively. Zone C, the unique zone within which efficiency change had positive effect, with a contribution share about 27.5% to its total production growth.

Biased Technological Change: Zone B ranked the first, with 13.5% contribution share to total production growth, and explained about 39.8% of the total technological change. Zone D had the contribution share 5.5% to total production growth, which was near the regional level 5%. Zone C was the smallest one 1.85% and zone A 7.7%.

Aside from the individual case, the land and irrigation elasticity increased thus their biased technological change increased. However, the labor and tractor elasticity decreased, and their contribution share to total production were deteriorated. Ultimately, the deterioration of biased technological change of labor and tractors were out balanced by land biased technological change as well as that of irrigation which had very small proportion.

Neutral Technological Change: The effect of neutral technological change on total production growth had a ascend trend in northern region from north part to south part: zone A, 13.3%; zone B, 20.4%; zone C, 42.6%; and zone D 44.3%. These statistic indicate that the effect of neutral technological change on total production growth in the lower north are higher than that in upper north. The neutral

technological contribution share to total production growth in northern region was 37.8% in during the period of 1975 - 1991.

5.4 the Policy Implications

The preceding analysis has important policy implications in promoting further agricultural growth and smoothing the inequalities among zones.

5.4.1 Increased Input Use

The quickest solution for northern region is to increase the use of inputs, such as land, labor, tractors and irrigation, and others. The potential of input uses to total production growth with respect to a specific zone will be discussed as follows:

1. Land: The harvested area was the most important factor in agricultural production with the largest elasticity (.498 in 1991, see Table 4.2) observed in this study. Increasing harvested area will considerably increase production in northern region. The contribution of harvested land area accounted only 2.4% to total production growth during 1975 - 1991 period. Table 2.4 showed that the annual average growth rate in zone D was only 0.4%, lower than the regional level 0.97%. In zone C, although the annual average growth rate of harvested area was 1.6%, a decrease of harvested area in zone C from 1981 to 1991 existed as well as the phenomenon observed in zone D (also see Figure 2.4, the harvested area reduced sharply from 1989 to 1991 both in zone C and zone D). Considering the contributions to total production growth in zones C and D were only 1.5% and 1.0% respectively, manage to increasing harvested area still would have a little more potential to total production in zone C and zone D.

To increase harvested area, even include zone A and zone B, can be done through the following two measures: (1) to expand planted area of rice and to increase

the intensity of cropping area; (2) to manage to reduce the damaged area. The reasons are: (1) some paddy land were left idle. For example, in 1991, the planted area for first and second rice in northern region was 12.8 million rais, but the arable land or holding land for paddy was 15.2 million rais. There was still 2.4 million rais left intact. (*Agricultural Statistical Year Book, Crop Year 1992/93*. OAE); (2) the damaged area was considerable. Still use the example of paddy area in 1991, the harvested area was 11.8 million rais, and damage area was 991,265 rais. The damaged area accounted for 7.72% of planted area.

Since the damage of planted area was not only the reduction of harvested area, but also the increase of production cost, strategically, it is essential to reduce the damage of planted area through land conservation program.

2. Labor: Increased use of labor had played an important role in the total production growth. At present, although the production elasticity of labor is decreasing, the elasticity was .36 in 1991 (ranked the second), the output from greater labor use is still potentially large. In zone A, from 1975 to 1991, the annual growth rate of labor was 2.3% (see Table 2.5), was the largest among the four zones, and the labor increase owned a contribution share of 54.5% to the total production growth. In zone B, despite the annual growth rate of labor and its contribution share were 0.3%, and 12.7%, lower than that of the regional level 1.4% and 22.6%, respectively. However, further increase of labor in zone A and zone B will have relative lower contribution to total production increase because the harvested area - labor ratios (see A-Table 9) in zone A and zone B were 2.45 rais and 5.01 rais per labor, lower than that of the regional level 5.33 rais per labor. Without an increase in land area, an increase in labor input will have only limited effect on total production according to the "law of diminishing return".

In the zones C and D, the following facts exist: (a) all the contribution shares of labor increase to total production growth (12.4%, and 9.9% respectively) were lower

than that of the regional level 22.6%; (b) the annual growth rate of labor input in zone D were and .6%, lower than that of the regional level 1.4%; (c) data showed that the labor shortage problem in Zone D and zone C still existed. In 1991, the harvested area - labor ratios in zone C and zone D were 6.71 and 10.45 rais per labor, respectively, which were larger than that of the regional level (5.33 rais / labor) though the annual growth rate of labor in zone C was higher than that of the regional level. Taking account of these above three facts, the potential to total production growth through increasing labor input in the zones C and D are still large, especially in zone D.

While examining the potential of labor increase to total production growth, the labor cost in the production process should also be considered. Because the labor input has become more expensive, the labor cost in production is increasing (see Table 5.2). An alternative solution to alleviate the labor shortage problem could be: to substitute tractors for labor. The details will be discussed in the next part (3. Tractor).

Table 5.2 Crop Farm Cash Expense Per Farm in Northern Region, Selected Crop Years

Unit : Baht/Farm

Crop Year	1986/87	1987/88	1988/89	1991/92
Total	6,217.27	9,522.48	11,714.58	11,274.56
Paid out for labor	1,494.30	2,919.93	2,828.09	6,258.55
Paid for machinery custom	1,072.40	1,528.30	1,951.42	-
Irrigation fee	8.96	5.60	17.34	38.63
Rented farm land	358.65	586.21	566.16	-
Others	3,282.96	4,482.44	6,351.57	-

Remark: 1. The average farm size in northern region from 1986/87 to 1991/92 crop years were 22.37, 23.02, 22.85, 23.02, 22.88, 22.93 rais, respectively.

Source: Office of Agricultural Economics (OAE).

3. Tractor: Table 5.1 showed that increased tractors will have potential in zone C and zone D area. Evidently, as mentioned in the above (2. Labor) part, in zone C and zone D, the harvested area taken care by per labor were larger than that of the regional level. The harvested area - tractor ratio (see A-Table 12) showed that in zone D, the harvested area served by per unit of tractor was 96 rais in 1991, larger than that of the regional level 63 rais. Hence, to increase tractor input would not only lessen the pressure from labor shortage problem, but also increase the contribution share of tractors to total production growth in zone D and zone C.

In the zones A and B area, the augmentation of tractor use had contributed relative large shares to total production during 1975 - 1991 period. Due to the relative large labor amount and the small operating land size per labor in zone A and zone B, increased tractor input will have less effect on production unless it increases land productivity. Thus, a top priority in increasing tractors involves increased land productivity in zone A and zone B area.

4. Irrigation: Table 5.1 showed that, in northern region the contribution from irrigation increase was very small (8.9%). In zone A and zone C, the contribution shares were even smaller than that of the regional level. Therefore, an increase of irrigated area will have a greater contribution to total production increase in the zones A and C. In zone B and zone C, despite their contributions was 18.6% and 31%, respectively, higher than that of the regional level 8.9%, the annual growth rate in zone B during 1975 - 1991 was only 10.34%, lower than that of the regional level 13.37%; in zone D, the irrigated area - harvested area ratio (see A-Table 14) in 1991 was 19.79%, lower than that of the regional level 28.58%. Accordingly, a increase of irrigated area likely has further potential for increasing total production in the zones B and D.

To increase irrigated area is necessary even it needs considerable investment (the investment cost will de discussed in the next paragraph). The reason is that the

availability of water at specific point in time is a crucial co-input for fertilizer and pesticides in the growth of the new high yield varieties. "A fall in the productivity of irrigated land will affect all other modern inputs and has a pervasive effect on overall agricultural performance." (Scandizzo, 1984).

Practically, to expend the irrigated area hardly can be done by local farmers themselves. It needs government investment because the newly irrigated land can be obtained only at sharply increasing costs in most part of the northern region as water for irrigation becomes less accessible and infrastructure more expensive (see Table 5.3). At the earlier stage of agricultural development, the easier availability of water and quality land made possible the realization of large canal schemes with storage reservoirs at a price of less than 15,000 Baht per hectare in 1956 - 66 period. The expansion of irrigated area, however, has been achieved at increasing unit cost of development of water sources and the infrastructure. The unit cost in 1976 - 85 period was 41,425 Baht per hectare.

Table 5.3 Area and Cost of Large and Medium Scale Irrigation Projects in NorthernRegion of Thailand (at 1986 constant prices)

Year of Construction	No. of Projects	Investment Cost	Irrigated Area Added(ha)	Cost (Baht / ha)
1956 - 65	9	4,841	308,320	14,538
1966 - 75	34	7,064	212,340	33,288
1976 - 85	94	9,546	230,434	41,425

Source: Isvilanonda *et al.*, 1994, 8.

Paralleling to the story of input expansion in the past two decades, there is a story of different contribution to growth of the various output. Since increasing input uses will certainly increase production cost, the long-run agricultural production increase should mainly focus on the technological change and efficiency improvement.

5.4.2 Technological Change

The results of this study indicate that technological change accounts for 42.8% of total production in the northern region of Thailand. The neutral technological change contributed 37.8%. If the technology adoption in 1972 was like Fuhs *et al.* stated that "Seed - Fertilizer" (green) revolution was still a dormant potential in Thailand, then it can be seen that the revolution had played its role in the northern region from 1975 to 1991. However, the neutral technological adoption in zone A and zone B only accounted for 13.3% and 20.4% of total production growth respectively, which were lower than that of the regional average level. Therefore, the potential of neutral technological progress on total production increase will be very large in zone A (37.8% - 13.3% = 24.5%) and also zone B (37.8% - 20.4% = 17.4%).

In terms of biased technological change, the contribution share to total production growth was 5.0% in this region. The biased technological change from land input (harvested area) in zone C contributed 2.44% to total production growth, lower than that of the regional level 6.67%. The biased technological change resulted from irrigated area in zone C was 0.03%, and in zone D was 0.76%, lower than that of the regional level 0.87%. Hence, the potential of increase total production from increasing land utilization effect in zone C and the effects of irrigated area in the zones C and D still exists in spite of the small shares.

According to the above analyses, the new strategy should focus on effective technological innovations, such as the adoption of new high yielding seed, new cropping methods, etc., especially in zone A and zone B area. Measures should be taken to ensure that the information on agricultural technology can be effectively defused to villages and farmers through the channels of research and extension. Besides the measures for neutral technological change, standing at the stead of biased technological improvement, the input factors should be utilized more efficiently through increasing the substitution capacity among the input mix.

5.4.3 Efficiency Improvement

The contribution share of efficiency improvement to total production growth was only 3.1% in northern region between 1975 and 1991. Except Zone C, in other three zones A, B, and D, there were negative efficiency growth rates (see Table 4.4), and subsequent negative effects on total production growth (see Table 5.1). In the cases that if the negative growth rates of efficiency had become zero, i.e., the production efficiency in 1991 maintained the same level as in 1975 in the zones A, B, and D, the contribution shares from efficiency change to total production growth would have avoided the contribution loss about 20.9%, 19.5%, and 8.6% in zone A, zone B and zone D, respectively. To this extent, the potential of increase total production from efficiency improvement still very large in these three zones. Compared with other Zones, The efficiency improvement will have grater potential in Zone B, where production efficiency was 75.7% in 1991, lower than the regional average level 81.3%.

To a less extent, for the northern region as a whole, if the production efficiency reaches the ever obtained 86.6% (in 1988) in the future, in other word, if the efficiency increases about five percent (86.6% in 1986 minus 81.3% in 1991), the efficiency induced production increase will be substantial.

Since the technical efficiency is determined by various factors both endogenous and exogenous of the production process, therefore, various relevant projects or programs can be conducted to detect the factors which influence the production efficiency, and in turn to improve the technical efficiency by a holistic approach.