CHAPTER 2

METHODOLOGY

2.1 Theoretical Framework

2.1.1 Induced change in institutions

Institutions as organized ways of doing things have two different functions; (1) contributing to the persistence, integrations, and stability of a certain society; (2) hindering the fulfillment of one or more of the society's requirements.

The disequilibria in economic relationships resulting from technical change is a major source of institutional change. As Hayami states, shifts in demand for institutional innovation are induced by changes in relative resource endowments and by technical change, the growing disequilibria in resource allocation resulting from institution constraints generated by the economic growth create opportunities for political leaders to organize collective action to bring about institutional changes. There is a recursive interactions between technical progress and institutional change.

Institutions, as a system, have the characteristic of resistance to change, institutional provisions generally lag in meeting emerging needs. Resource constraints and progress in technology are the powerful inducements to institutional change (Hayami and Ruttan, 1985).

Institutional change, in turn, serves the needs of new technology, and improves technical efficiency.

2.1.2 Technological change

Technology innovation as an endogenous variable to the economic system, can facilitate the substitution of relatively abundant factors for relatively scarce factors in economy which is induced by the resource constraints (Hayami et al., 1985). Hicks´ theory implies that a rise in the price of one factor relative to that of other factors induces a sequence of technical changes that reduce the use of that factor relative to the use of other inputs. As a result, the constraints on the economic growth imposed by resource scarcity are released by technical advances that facilitate the substitution of relatively abundant factor for relatively scarce factors (Hayami et al.,1985).

There are two major kinds of technology in agriculture: mechanical technology being in the category of labor-saving technology, and biological and chemical technology in land-saving type.

Technology innovation leads to increases in productivity. In details, increase in productivity can be traced to following sources (Peterson and Hayami, 1977): improvement in human resource, namely, increase in farming skills, and increase in quality of nonhuman capital, such as quality improvement of machinery and relevant equipments, increase in quality of other inputs, e.g. crop variety, improved chemical, etc., and thus, improvement in the quality of output.

2.2 Scope and Limitation

Most of the earlier studies concentrated on descriptions of the mechanism of agricultural production growth in 1978-1984. Their emphasis was on discussions of one or two sources ignoring others which are also important contributors to the production growth. **Their studies did not identify and separate the effects of different factors on agricultural production growth, too.**

Available quantitative studies on agricultural production growth were done by Lin (1987) and McMillian, Whalley, and Zhu (1989). Lin's study underscored exclusively on institutional reform, **the effects of technological change on agricultural production and productivity growth were ignored.** In another study by WcWillian, the effect of technological change was also put aside, focus of his study was on agricultural product price and incentive system provided by the economic reform during 1978-1984.

Fan's study (1991) improved both studies above by considering the effects of institutional reform, increase in input use, and technological change simultaneously. Results of Fan's study indicated that in **different regions the effects of institution and technological change were different.**

In relation to study on agricultural production fluctuations, quite a few arbitrary statements have been made, few detailed investigations were conducted.

After reviewing relevant literature, it has become quite clear that conducting a study considering institution, technology, and input use increase at the same time to find out their explicit effects on

Guizhou's crop production is necessary.

The focus of this study is on: understanding the present institutions and analyzing its effects on Guizhou's agriculture, especially the crop production; identification of impacts of technological change, inputs increase, and institutional reform on Guizhou's crop production; investigation on reasons resulting in crop production fluctuation.

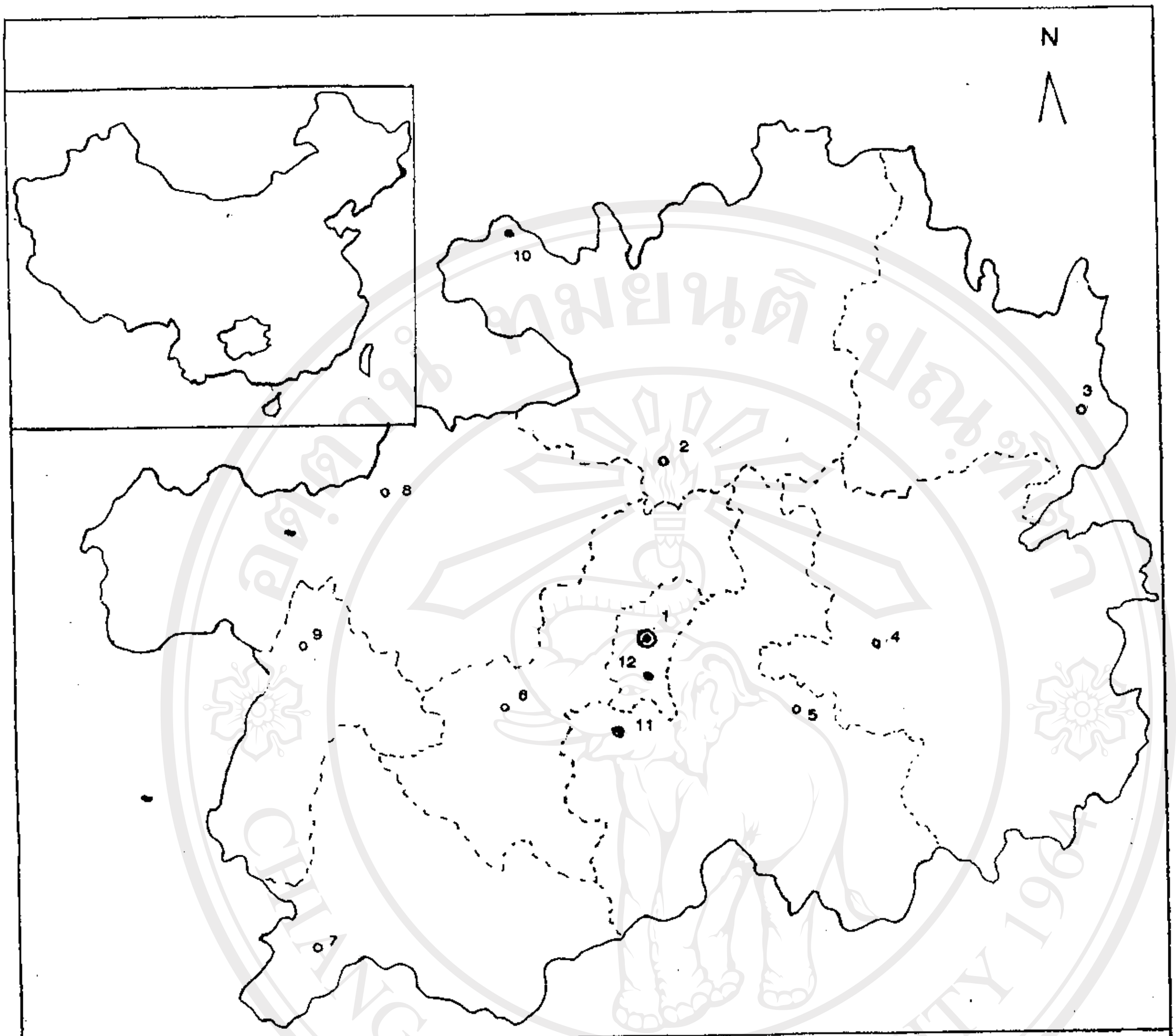
2.3 Data Collection

In this study, time-series data from 1952 to 1990 and social survey data were collected. The Information Research Institute of GAAS, Guizhou Agricultural Bureau, and Guizhou Statistics Bureau served as the major sources of historical data. Socioeconomic survey data was collected through a socioeconomic survey at three villages (Figure 1.) purposely chosen to represent the whole province. The multi-staged socioeconomic survey method was employed, which consisted of:

A. Diagnostic stage. The purposes of the diagnostic phase are as follows: (1) to describe and understand the present institutions, its effects on agricultural production; (2) to understand performance of agricultural systems in Guizhou province; (3) to collect information used to design a formal survey which was subsequently carried out.

The diagnostic phrase was divided into two parts:

-- Gathering and viewing of secondary information. Through viewing of secondary information on geography, climate, population, economic development, and social differences, survey sites were chosen.



Source: Guizhou Economic Maunal, 1984.

Legend

⊙ Provincial capital
o Prefecture capital
• village

1. Guiyang 2. Zunyi 3. Tongren
4. Kaili 5. Duyun 6. Anshun
7. Xinyi 8. Bijie 9. Liupanshui
10. Jiantan 11. Kaizuo 12. Huaxi

Figure 1. Location Map of Social Survey

-- Conducting of informal survey. By interviewing farmers and key informants to examine the nature of the production system under present institutions, in order to obtain a broad perspective of the present institutions.

B. Problem identification stage. On the basis of informal survey, key questions and issues were derived, structured interview technique was employed.

Totally 180 households, 60 households each village, were interviewed.

2.4 Data Gathered

Data collected in social survey is:

Socio-economic Profile Data: farm size, land (Paddy field, upland, etc.), household size, number of dependents in family. etc..

Specific variables are:

(a) institutions in relation to resources utilization, land distribution, water and labor use pattern. From the viewpoint of institution, to find out the constraints on further development of crop production;

(b) Infrastructure building and public service facilities management, access for farmers and resources management;

(c) Marketing systems for agricultural outputs and inputs, and modern inputs use;

(d) The present technology diffusion system and its functions under present institutions.

Crop Production Data----cultivated area, crops planted, yield, types and amount of inputs used, input and output marketing.

Time series data including:

Output data----- total value of agricultural production, including crop production, forestry, husbandry, sideline, and fishery. Gross value of main cereal and economic crops, including rice, corn, wheat, oilseed, soybean, tobacco, groundnut, sugarcane, potato, etc..

Input data---Land, labor, draft animal, irrigated area, chemical fertilizer, and manure fertilizer.

2.5 Analytical Framework

According to the production theory, total production growth rate consists of movements along the production function (because of the increase in total inputs use), and shift of production function (because of the change in technology). Under the assumption that production of firm is perfectly efficient, the growth rate of production is equal to that the growth rate of total output minus the growth rate of total inputs. This assumption is not realistic, however, if this assumption is relaxed, the growth rate of production can be attributed to efficiency improvement as well as technological change and increase of inputs use (Fan 1991). Figure 2 shows the principle used to separate the effects on production change of different sources (adopted from Fan, 1991).

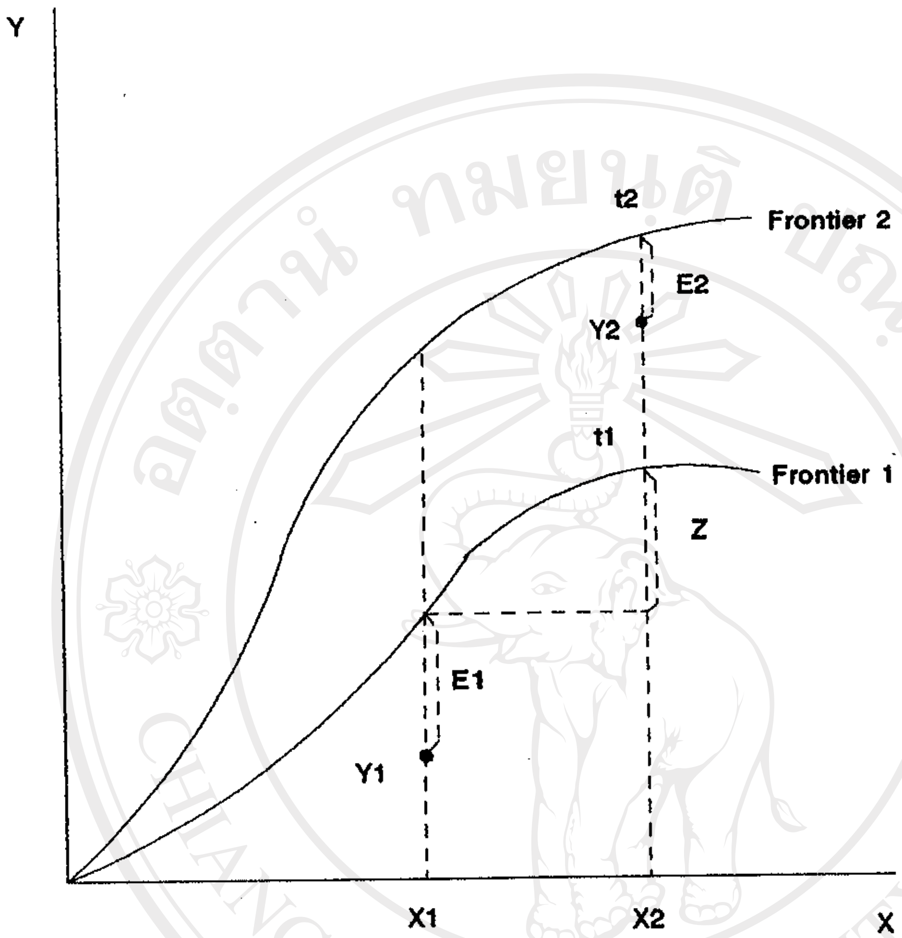


Figure 2. Effects on production growth of input increase, technological change, and efficiency improvement

In Figure 2 at time 1 and 2 the producer has production frontiers 1 and 2, if the production processes are perfectly efficient, output should be on the frontiers, however, the actual output may be at Y_1 at time 1 and Y_2 at time 2, owing to the inefficiency of production. Technological change can be measured as the shift in production frontier, i.e., $t_2 - t_1$. Inefficiency is measured by the change in the distance between frontier and the realized output, i. e., E_1 and E_2 at corresponding moment of time. Thus, the efficiency improvement over time can be reflected by the difference of E_1 and E_2. While the contribution of input use increase across time is measured by Z. Therefore, the output change in crop production can be analyzed by the following formula:

$$Y_2 - Y_1 = Z + (t_2 - t_1) + (E_1 - E_2) \qquad (1)$$

2.6 Model Specification

2.6.1 Technical efficiency estimation

For a frontier production function, the following general form can be considered:

$$Y_{it} = f(X_{it}, b)\, e^{v_{it}} e^{u_{it}}, \qquad (2)$$

by taking logarithm on both sides of function (2), then

$$LnY_{it} = Lnf(X_{it}, b) + v_{it} + u_{it} \qquad (3)$$

where i denotes the ith firm, and t denotes time; Y_{it} is output; x_{it} is $1 \times k$ rows of inputs at time t; $f(x_{it}, b)$ is the potential output; v_{it} is a stochastic variable standing for uncontrollable random effects in the process of production; u_{it} is one-sided distribution, defined as technical inefficiency, therefore, $u \leq o$. In (2), $f(x_{it}, b)e^{v_{it}}$ is the stochastic frontier production function, given that v_{it} are those factors beyond the firm's control. The nonpositive disturbance u indicates that output must be below the frontier $f(x_{it}, b)e^{v_{it}}$, since $e^{u_{it}}$ takes the values between zero and one. Under the assumption that inefficiency may be changing with time by learning from the past experience, following conditions hold:

$$E(u_{it}\, u_{it'}) = 0 \quad \text{for all } i, \text{ and } t \neq t'$$

$$E(u_{it}\, u_{jt'}) = 0 \quad \text{for all } i \neq j,\ t = t'$$

Also, assume that u is truncated normal distribution with variance σ_u^2, v is disturbance term of normal distribution with mean zero and variance σ_v^2, and no correlation between u and v, namely, $E(u_{it}v_{it}) = 0$.

The efficiency for a firm at time t, then is defined as follows:

$$\frac{Y_{it}}{f(X_{it}, b)\, e^{v_{it}}}$$

Since v_{it} is unobservable, the efficiency of a particular firm can not be measured. Fortunately, Kalirajan and Flinn (1983) provided an approach to solve this problem. Based on the conditional distribution of u_{it} given the distribution of $v_{it} + u_{it}$, the efficiency of a specific firm at given time can be measured as:

$$E[\exp(\frac{u_{it}}{u_{it}+v_{it}})]=\exp[-(\frac{\sigma_u\sigma_v}{\sigma})(\frac{f(.)}{1-F(.)}-\frac{\varepsilon_{it}}{\sigma}\frac{\sqrt{\gamma}}{1-\gamma})] \quad (4)$$

Where $\epsilon_{it} = v_{it} + u_{it}$, σ is the standard error of ϵ_{it}, $\gamma=\sigma_u^2/\sigma^2$, f(.)and F(.) are the values of the standard normal density function and standard normal distribution function evaluated at:

$$\frac{\varepsilon_{it}\sqrt{\gamma}}{\sigma(1-\gamma)}$$

2.6.2 Selection of the functional form

Production of single output by using multi-input n, can be described as the following production function:

$$Y_t=f(X_{1t}\ldots,\ldots X_{nt},t) \quad (5)$$

where Y_t is output and x_{it} is ith input at time t, t is time trend to capture the technological change. The unrestricted translog functional form can be utilized to represent production function (5). Considering the statistical problem of multicollinearity and considerable data caused and required by this functional form, under the restriction of that all inputs are separable from each other and each input can not be separated from technological progress. Thus input i denoted by X_{it} can be defined as $g_i(x_{it}, t)$.

$$Y_t = f[g_1(X_{1t}, t), \ldots g_n(X_{nt}, t)]. \qquad (6)$$

Function (6) is based on the theoretical background of the facts that every input changes over time while the effects among inputs are indirect on production through time and then not considered. The following function is to represent (6)

$$Ln(Y_t) = a_0 + a_t t + \sum_i a_i Ln(X_{it}) + \sum_i a_{it} Ln(X_{it})\, t + a_{tt} t^2 \qquad (7)$$

If all inputs and time are considered separable, then the production will be

$$Y_t = f[g_1(X_{1t}), \ldots, \ldots g_n(X_{nt}), t] \qquad (8)$$

Cobb-Douglas production function can be applied to explain (8)

$$Ln(Y_t) = a_0 + \sum_i a_i Ln(X_{it}) + a_t t. \qquad (9)$$

Production function (7) can be changed to:

$$LnY_t(t)=a_0+\sum_i a_i LnX_{it}(t)+\sum_i a_{it}(LnX_{it}(t))\,t$$

$$+a_t t+a_{tt}t^2+Ln(e^{u(t)})+v(t) \qquad (10)$$

Then,

$$LnY(t)=LnA_0(t)+\sum_i a_i(t)\,Lnx_{it}(t)+LnE(t)\,. \qquad (11)$$

and where,

$$LnA_0(t)=a_0+a_t t+a_{tt}t^2+v(t)\,,$$

$$a_i(t)=a_i+a_{it}t,\ E(t)=e^{u(t)}$$

The partial derivative of (11) with respect to time t, can be used to account for the growth of total value of crop production.

$$\partial LnY(t)/\partial t=\partial LnA_0(t)/\partial t+\sum_i a_i(t)\,\partial LnX_{it}(t)/\partial t$$

$$+\sum_i LnX_{it}(t)\,\partial a_i(t)/\partial t+\partial LnE(t)/\partial t. \qquad (12)$$

Where $\delta LnE(t)/\delta t$ is technical efficiency change over time measuring the effects of institutional reform on crop production. The first term in (12) expresses the neutral technological change, the second term measures the effect of input on crop production change. The third term explains the effect of biased technological change.