ABSTRACT

Zeng, Tao. Chinese Agricultural Household Farming Efficiency and Off-Farm Labor Supply. (Under the direction of professor Barry K. Goodwin)

This dissertation deals with the off-farm labor supply of Chinese agricultural households. The data used in this study are from the World Bank's 1995 North and Northeast China Living Standards Survey. The objectives are two fold. The first objective explores the relationship between the farm operators' off-farm labor supply and the household's farming efficiency, and identifies the factors affecting the farm operators' off-farm labor supply. Alternative approaches are used to measure farming efficiency. The theoretical model predicts an inverse relationship between farming efficiency and off-farm labor supply. However, the empirical results show that the crop production technical efficiency is positively related to off-farm labor supply and the agricultural production technical efficiency exhibits no significant effect on off-farm labor supply. There appears to be a surplus of labor in the agrarian sector in China. Restrictions on the movement of labor among regions and in the reallocation of farmland serve to maintain this surplus and thus bring about economic inefficiencies.

The second objective investigates the switching nature of the operator's off-farm labor supply depending on the spouse's participation status in off-farm labor markets. An endogenous switching regression model shows that the spouse's participation status is endogenous to the operator's off-farm labor supply decision. The off-farm labor supply

behavior of operators with spouses working off-farm exhibits some differences from that of the operators with spouses' not working off-farm. The results support that the agricultural household is a more relevant decision unit for resource allocation than is its individual members.

Chinese Agricultural Household

Farming Efficiency and Off-Farm Labor Supply

by

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A dissertation submitted to the Graduate Faculty of
North Carolina State University
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

Economics

Raleigh, NC

2005

Approved by:

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BIOGRAPHY

Tao Zeng was born in Hunan, China in 1976. She received her B.A. of Economics from Xiangtan University in 1997. Then, she stayed there in the Master Program of Economics. She joined the Department of Economics at North Carolina State University in August 2000 for her doctoral study. She passed her final oral examination for Ph. D. in Economics with minor in Statistics in May 2005.

ACKNOWLEDGMENTS

I would first like to thank Dr. Barry K. Goodwin for his excellent guidance throughout the course of this study. As chairman of my Advisory Committee, he has generously provided his time, insights, and encouragement. This dissertation would be impossible without his help. I am also very grateful to my other committee members: Dr. Duncan M. Holthausen, Dr. Daniel J. Phaneuf, Dr. Leonard A. Stefanski and Dr. Walter N. Thurman, for improving this research through their constructive suggestions and comments. I would also like to thank Dr. Holthausen and Dr. Thurman for the advice and inspiration they provided during my study at N.C.State.

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Chapter 1

Introduction

1.1 Introduction of the Problem

The movement of labor away from the agricultural sector has long been considered to be an essential feature of economic development, both historically in developed countries and currently in developing ones. The economic development process is usually featured by the release of labor and other productive resources from agriculture. Migration of labor out of agriculture may result as permanent movement of labor from one location or sector to another. Alternatively, labor may be reallocated between farm and off-farm sectors through the effects of part-time or full-time off-farm employment of farmers. The allocation of labor among agricultural and nonagricultural sectors is an especially important feature of market development in transition economies.

Since economic reform began in the late 1970's, the rural economy in China has experienced rapid growth. Chinese rural workers enjoy more freedom to choose their occupations and to divide their labor among household farming and non-farm employment. These opportunities have grown over the last two decades, especially after the 1990s market-oriented reforms. Some estimates showed that off-farm rural employment in China rose from less than 40 million in 1981 to more than 150 million farmers in 1995, a growth in off-farm employment of more than 100 million farmers (DeBrauw, Huang, Rozelle and etc 2002). In contrast, before the 1970s rural household members had no alternative to collectivized farming. With an unfavorable ratio of farmland to rural labor of 0.144 hectares, (compared to 0.221 for India, 2.729 for the

U.S., and 0.426 for the world) and a perceived surplus in the agricultural labor supply, off-farm employment has become an important source of income and employment for Chinese rural households. Giles (2002) showed that in China, as in other regions of the developing world, access to off-farm labor markets can help rural households reduce vulnerability to agricultural production shocks.

In order to modernize successfully, China must rely on labor markets to facilitate the shift from a largely rural population to an urban one. General economic development causes increases in off-farm wages and in off-farm employment opportunities. From the perspective of agricultural households, it is rational to allocate the resources including labor supply in a way so that the utility is maximized rather than to only rely on agricultural production. Accordingly, the off-farm labor supply of farming households is one of the important aspects of resource allocation in farming households as well as of structure changes in agriculture.

1.2 Objectives

The general objective of this research is to examine the labor supply responses of Chinese farm households to changes in economic opportunities. The first objective is to identify factors affecting the amount of time supplied to off-farm employment by farm operators and their respective effects. Particular attention is given to the relationship of household specific farming efficiency and the off-farm labor supply of farm operators, since off-farm labor supply can induce changes in the structure of agricultural product supply and factor demand functions. Much previous research has been focused on the growth of total agricultural productivity. Some work has aimed to investigate the effect of migration of farmers on the total grain output from a macro perspective. Little research has been targeted at household agricultural productivity and its relationship with the household's off-farm labor supply. Cook (1999) studied labor allocation and productivity at the household level; though her analysis is based on a single county and is not generalizable to all of China. Cook concluded that contemporary Chinese agriculture is characterized by a surplus labor supply, suggesting that agricultural output will not be reduced with the surplus labor transferred out of agriculture. Rozelle et al. (1999) traced the linkages among migration, remittance, and agricultural productivity. They found that temporary migration depressed yields, suggesting that there is no existence of labor surplus at the household level, which contradicts Cook's results. In this dissertation, different approaches are employed to derive household specific farming efficiency for Chinese agricultural households. The analysis will enrich our knowledge to understand the role played by off-farm labor supply in the structural changes in the agricultural sector.

The second objective is to investigate the switching nature of the operator's off-farm labor supply depending on the spouse's participation status in off-farm labor markets. The intrafamily interdependence is of importance because the farm household is a more relevant decision unit for resource allocation and consumption than is its individual members. Even when policy measures or changes only touch on the labor allocation decision of certain group of household members directly (for example, male farmers), the policy changes would also affect time allocation decision of their spouses and consequently agricultural resource allocation in general. Few studies about labor allocation in rural China have taken this aspect into account. Analysis of this theme in this dissertation will provide information that may be important for the design and coordination of economic policies that affect the rural regions because it can help to improve conformity between political goals and measures.

1.3 Theoretical Framework and Data for Empirical Analysis

The agricultural household model has been a popular approach to the analysis of off-farm labor supply of agricultural households. The decision units are single agricultural households. Household members' welfare is assumed to be summarized in a single hybrid, household-utility function, which combines utility maximization, analysis of consumption, production, and labor supply decisions. This dissertation adopts the agricultural household model as the basis for theoretical discussions. The central part of this research is the off-farm labor supply of Chinese agricultural households; accordingly the model presentation and the discussion will be concentrated on the time allocation problem. The model structure will be presented and extended to the problem at issue in chapter 4 and chapter 5. Chapter 6 follows the same model as chapter 4.

The data used in this study are from the World Bank's North and Northeast China Living Standards Survey[1]. The survey was carried out in the summer of 1995. It covered 787 households in 6 counties, 18 townships and 30 villages in the northern province of Hebei and the northeast province of Liaoning. The counties and villages were not selected randomly[2]. Each of these counties was the site of an intensive

[1] Information about World Bank's Living Standards Survey, see "A Guide to Living Standard Measurement Study Surveys and Their Data Sets " http://www.worldbank.org/html/prdph/lsms/guide/guide.pdf
Information about World Bank's North and Northeast China Living Standard Survey, please see http://www.worldbank.org/lsms/country/china/docs/chnbinfo.pdf

[2] The sample is not a rigorous random sample drawn from a well-defined population. Instead it is only a rough approximation of rural population in Hebei and Liaoning provinces in Northeastern China. The reason for this is that part of the motivation for the survey was to compare the current conditions with conditions that existed in Hebai and Liaoning in the 1930's. Three counties in Hebei and three counties in Liaoning were selected as "primary sampling units" because data had been collected from those six counties by the Japanese occupation government in the 1930's. Within each of these six counties five

household level investigation carried out by Japanese investigators in 1936. Five villages in each of the six counties were selected, one of which had been fully enumerated in the 1930s. The other four villages in each county were drawn to be as representative of a cross-section as possible. They included one village located in the same township as the administrative capital of the county; one village located in the same township as the village surveyed in the 1930s; and two villages drawn from a third township. A total of 130 households were surveyed in each county: fifty from the village surveyed in the 1930s and twenty from each of the remaining four villages. The households were selected based on random sampling using the most recent village registry.

When Japanese General Kodama Gentaro and Goto Shimpei formulated their colonial policy to develop its resources to serve Japan's long-range imperial interest in the late 19th century, they started their interest in Chinese rural conditions. Goto Shimpei believed that a thorough study of social and economic institutions was necessary before introducing major reforms to a traditional society so as to anticipate their impact and to minimize the costs and difficulties of colonial rule. "To shed light on Chinese society in order that its legal and economic system be revamped and a comprehensive plan

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villages were selected, for an overall total of 30 villages (in fact, an administrative change in one village led to 31 villages being selected). In each county a "main village" was selected that was in fact a village that had been surveyed in the 1930s. Because of the interest in these villages 50 households were selected from each of these six villages (one for each of the six counties). In addition, four other villages were selected in each county. These other villages were not drawn randomly but were selected so as to "represent" variation within the county. Within each of these villages 20 households were selected for interviews. Thus the intended sample size was 780 households, 130 from each county. The selection of households within each village was done according to standard sample selection procedures. In each village, a list of all households in the village was obtained from village leaders. An "interval" was calculated as the number of the households in the village divided by the number of households desired for the sample (50 for main villages and 20 for other villages). For the list of households, a random number was drawn between 1 and the interval number. This was used as a starting point. The interval was then added to this number to get a second number, then the interval was added to this second number to get a third number, and so on. The set of numbers produced were the numbers used to select the households, in terms of their order on the list.

formulated for Japan to follow with respect to her China policy", several Japanese research organizations formulated their ambitious programs for the economic and political study of mainland China.

In 1934 in Japanese-occupied Manchuria (present-day northeast China), the Japanese established a Provisional Industrial Investigation Bureau in the Ministry of Enterprises of the National Affairs Yuan of Manchukuo. The First Section of the Bureau was to survey villages in different counties for a five-year period and produce evidence to enable policy makers to understand rural economic conditions throughout Manchuria.

The first survey was conducted in late February 1935, which resulted in the publication of a three-volume study in April 1936. Conditions of seventeen villages of sixteen counties throughout north Manchuria for 1934-35 were reported. Another survey commenced in late February 1936 in twenty-one more villages of twenty-one other counties, mainly located in south Manchuria (present-day Liaoning province). This survey led to the publication in December 1936 of four volumes reporting village conditions for 1935-36. Separate county and village studies were made again in 1937 and 1938.

The 1936 survey included 1,049 households residing in 21 villages in 21 counties, with supplementary information compiled for each of these villages on four to six outlying villages. The villages were selected to reflect the diversity of geographic and economic conditions in Manchuria. Most of the villages are located in the south of Shen-yang (Capital of Liaoning province), and were typically located within 20 kilometers of the county seat. Myers, Benjamin and Brandt have worked with the data and they believe that the data is of good quality despite the fact that it was collected by an occupying power, because the Japanese investigators worked with local village officials and elites in order to obtain the cooperation of households in the survey.

The North China Economic Research office of the Mantetsu chosabu launched a ten-year research plan with a budget outlay of 5.5 million yen. They proposed a study of land tenure systems in Shandong, Hebei, and Inner Mongolia, to be followed with field studies of commercial customs and organizations in Kiangsu and Chekiang.

Liaoning Province lies in the northeastern part of China, surrounded by Jilin, Inner Mongolia and Hebei, and bordering on the Democratic People's Republic of Korea to the east and by the Yalu River. Liaoning is one of the most important heavy industry production bases in China. In the course of recent years, township enterprises have become an important pillar of Liaoning's economy. Hebei Province lies to the north of the lower Yellow River and to the west of Bohai Sea with a coastline about 500 km long. It borders on Liaoning, Inner Mongolia, Shanxi, Henan, and Shandong provinces. Hebei has a long history of agriculture, and is one of the important areas for production of grain and cotton in China. Animal husbandry and fisheries are also important components of the economy. In both Liaoning and Hebei, agriculture remains a dominant source of income, but the development of local off-farm employment enables households to cultivate their allocated land as a basic form of security while undertaking more lucrative non agricultural activities to increase their income. Therefore, in contrast to some research that has focused on only the poorest areas or the rapidly developing regions, the study of Liaoning and Hebei provides a more representative rural area.

The survey provides detailed information about household characteristics (e.g. demographic structure, education, housing conditions, farm size) and economic activities (e.g. farm management, own non-agricultural business, off-farm jobs, household expenditures, gifts, remittances, savings and loans). The sample includes 2183 individuals, 52.04 percent being male workers. The average per capita income in the sample is 3510 Yuan, or about US $442. Farm income accounts for nearly half of total household income. Nearly three-quarters of farm income is from crops and the rest is from sideline enterprises such as vegetable gardens and greenhouses. More than 45 percent of the population worked off-farm, of which nearly 70 percent were male workers. About 95 percent of individuals hold agricultural registration status. Twelve out of thirty one villages have local rural enterprises, where 35.36 percent of the population resides. Off-farm activities include family-run business and off-farm wage employment. The occupation survey part contains detailed information about days and hours worked on farm during the busy season and non-busy season, and detailed information about months, days and hours worked off-farm in the year of 1994.

1.4 Overview

The dissertation proceeds in the following manner. Chapter 2 describes briefly the situation of the rural labor market and the rural economic reform in China, which serves as prerequisite for understanding the empirical analysis—definition of variables and empirical results in the following chapters. Chapter 3 reviews the previous research that has been done about Chinese off-farm labor markets as well as studies about off-farm labor markets in the USA and other developed countries. Chapters 4, 5 and 6 form the heart of the dissertation, to accomplish the objectives mentioned in section 1.2. Chapter

4 uses bootstrapping techniques to obtain a simplified simultaneous-equation Tobit estimator for the operators' off-farm labor supply. Farming efficiency is represented by using instrumental variables. Chapter 5 adopts a switching regression model to investigate the switching nature of the operator's off-farm labor supply with regard to the spouse's participation decision in off-farm labor market. Chapter 6 employs stochastic production frontier estimation methods to derive household specific farming efficiency and investigate its relationship with the operator's off-farm labor supply. In conclusion, Chapter 7 summarizes the theoretical discussion and the empirical analysis of the research.

Chapter 2

Rural Labor Market in China

This chapter describes the economic reform in rural China and the structural changes of the rural labor market, based on official statistics as well as results from some earlier research. Section 2.1 briefly describes the general situation in the rural labor market before the economic reform. Section 2.2 gives a picture of the rural economic reform, which started in 1978. Section 2.3 marks out the changing rural labor market. This presentation serves as prerequisite to understand the empirical work in chapter 4, chapter 5 and chapter 6.

2.1 Pre-Reform Labor Arrangements

A fundamental characteristic of the Chinese economy under central planning is the formal segregation of the agricultural-centered rural and manufacturing-centered urban economies and labor forces. Under central planning, starting in 1949, the two sectors were treated as separate entities, though critically linked to each other. Still underlying Chinese labor-market problems and policies today, the segregation leads to major problems of incentives, mobility, wage differences, and social policy between rural and urban sectors. The division between state and non-state ownership sectors; social-security like medical coverage and pensions and unemployment insurance; and related topics of housing, education, and other social services differ tremendously between rural and urban economies. During the period of central planning, the Chinese government pursued a heavy-industry-oriented development strategy, which aimed at achieving rapid industrialization by extracting agricultural surplus for capital accumulation in industries and for supporting urban-based subsidies. To enforce this strategy, agricultural commodities were unifiedly procured and sold; and the entire population's place of residency and work were designated by the People's Communes[1] and Household Registration System (for an explanation, see page 16). This development strategy resulted in distortions in factor markets with an excessive concentration of capital in urban areas and of labor in rural areas.

The labor force in rural areas was governed under the People's Communes, which received production targets from the planning authorities and delivered procurements at state-dictated low prices. Ever since the tragic famine of the Great-Leap-Forward[2] in 1959-61, national policies stressed agricultural production and local grain self-sufficiency. Rural industries were underdeveloped and remained subsidiary to agriculture. Before 1978, Maoist policies of egalitarian distribution-"eating from the same big pot" discouraged incentives within the rural economy. Labor rewards were not related to agricultural output or the actual work done but rather to time spent in the fields by workers. This policy offered little incentive for an individual to be efficient or hard working and encouraged free-rider behavior. There were two sets of problems in the

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3 People's Communes were initially created in 1958 to institute a more egalitarian mode of production as part of the Great Leap Forward. Communes comprised about 5,000 households on average. All property was jointly owned and income was distributed according to a work-point system that undervalued individual contribution. Communes possessed governmental, political, and economic functions. Beneath communes in the organizational hierarchy were production brigades and production teams. With the agricultural reforms of the early 1980s the commune system was slowly disbanded, replaced by townships in most areas by 1985.

4 A utopian campaign started in 1958 and sought to make China an advanced industrial country in the span of several decades by employing mass collectivization and mass political mobilization. The campaign resulted in economic disaster and a devastating famine. By the time the GLF was abandoned in 1960, tens of millions had died of starvation.

labor market under central planning: (1) labor incentive problems due to the organization of work within communes, and (2) misallocation of labor between rural and urban sectors, as well as between agricultural and non-agricultural sectors within rural regions.

2.2 Rural Economic Reform

Market-oriented development in rural China started with a package of three reforms: the replacement of production teams with the Household Responsibility System, official increases in agricultural product prices, and the liberalization of markets for rural products. These reforms provided the necessary conditions for the boom in rural industrial development starting in the mid-1980s, and were instrumental for the emergence of labor markets in rural China.

Economic reform in the countryside resulted from a reaction from those enduring extremely poor living conditions. Between 1976 and 1977, a production team in Anhui province secretly initiated a partial privatization movement. The farmers were so trapped in poverty that they did not particularly care if they would be caught and punished by the government. They divided their team's land into equal-sized small pieces and allocated each family member their share. Contracts were made between the production team with each family, requiring each family to pay an amount of grain to the government and the production team. A family could retain the rest of their output. Since individual households took responsibility for agricultural production and their efforts were directly rewarded, family work effort was strongly encouraged. By the end of the year, the production team's total output more than doubled and the farmers had enough to feed themselves. Many production teams followed the example the year after and all successfully increased their output and family income. Finally, the Chinese government realized that it is the way for farmers to get out of poverty and hunger. Based on these spontaneous experiments, the Household Responsibility System (HRS) was introduced to the whole country in 1978 and was essentially completed in 1983.

The HRS enabled resource allocation, production structure and income distribution among family members to be household decisions, provided that the quotas and levies were met. Meanwhile, the government also started reforms on production planning by reducing the number of production planning targets or categories. Many of the remaining targets were directed by complementary prices and incentive schemes. Farmers then not only were inspired to work hard but also had certain individual freedom to seek off-farm employment. Households decided who worked on which plot of land or which off-farm activity according to individual members' abilities. Their efforts were directly rewarded in the form of household income. Assuming that a household is an integrated decision-making agent who maximizes household's rather than individuals' utility; the "free-rider" problem could easily be solved under the HRS. Many studies have shown that the rapid growth of labor productivity in rural China is a direct result of these institutional changes (Lin, 1988).

The government also substantially raised state procurement prices for agricultural products. During the years 1978-84, prices for grain procurement were increased by 98.1 percent, for oil-bearing crops by 51.8 percent, and for cotton by 56.9 percent (calculated from State Statistical Bureau 1995: 247-48). The state also raised the bonuses for above quota procurement from 30 percent of the state fixed price to 50 percent. During 1980-86, the government reduced the number of agricultural goods under direct state pricing control from 113 to 17. Moreover, the state gradually replaced the old state pricing system (the state set the prices of industrial goods near or above the market price while setting prices for agricultural products below their market value, which comparatively undervalued agricultural products), with a two-tiered pricing mechanism. The government continued to set basic procurement prices for essential agricultural products including grains, vegetable oils, and cotton; however, state officials also set “negotiable prices”, or prices more accurately reflecting market value, for products sold above fixed quotas. Finally, the government slowly increased the number and type of goods that farmers could sell at local markets at floating prices independent of state control. These price adjustments injected a large amount of funds into the rural economy, which created a demand for industrial products and supplied funds for capital investment, especially non-farm production. The liberalization of rural markets accommodated the sales of non-farm products and facilitated the purchase of inputs for nonagricultural activities.

Consequently, by the mid-1980s, the economic basis for accelerated growth in rural industries was embedded in China’s rural economy. Input and output markets had emerged; households were conscious of their alternative opportunities; and they had incentives to quickly allocate resources to nonagricultural activities that would generate higher returns than those from farming. There is little question that the marginal productivity of capital and labor in the non-farm sector of the rural economy exceeded the levels in the cropping sector, indicating over-allocation of resources to agriculture (Putterman, 1993). A series of government regulations enacted in the 1980s loosened restrictions on labor mobility, catalyzing the rapid expansion of non-farm production that could absorb labor released by the increasingly productive farming sector.

In 1983, Document No.1 of the Central Committee of the Chinese Communist Party released general guidelines to encourage the emergence of specialized households[3] and their effectiveness in making the best use of limited funds and labor. Skilled workers and craftsman were permitted to leave farming and engage in a variety of non-agricultural activities, including long distance transport and the marketing of commodities. The document also allowed cooperative ventures, rural-industrial and commercial households to hire labor. In 1984, the Central Committee of the Chinese Communist Party and the State Council issued the "Report on Creating a New Situation in Commune and Brigade-run Enterprises," which outlined a new development strategy focusing on rural industry development. Rural industrial development was expected to provide inputs for agriculture, to absorb rural labor, and to help raise rural incomes. In 1985, Document No.1 permitted farmers to seek employment and establish business in nearby towns, if they were able to provide their own food grain and were financially able to run a business. This deregulation officially allowed labor mobility within rural regimes.

In addition to the relaxation of controls on labor mobility, a major reform in agricultural production and procurement helped stimulate the fast expansion of rural industries. At the beginning of 1985, after consecutive years of good crop harvests, the

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3 In the 1980s, market activity played a central role in the rural economy. Farmers sold a growing share of their produce in rural or urban free markets and purchased many of the inputs that had formerly been supplied by the team or brigade. A prominent new institution that thrived in the market environment was the "specialized household." Specialized households operated in the classic pattern of the entrepreneur, buying or renting equipment to produce a good or service that was in short supply locally. Some of the most common specialties were trucking, chicken raising, pig raising, and technical agricultural services, such as irrigation and pest control. Many of the specialized households became quite wealthy relative to the average farmer.

state announced that it would no longer set any mandatory production plans in agriculture and that purchasing contracts negotiated between the state and farmers were to replace obligatory procurement quotas. The loosening of farming constraints, together with the increased freedom in resource allocation decisions, enabled farmers to adjust their productive activities in accordance with profit margins.

In 1985, the grain-sown area at the national level fell by 4 percent, cotton-sown area fell by 26 percent. In contrast, the number of TVEs (township and village enterprise) more than doubled in the same year, and their total labor force increased by 36.5 percent, following a year of strong growth in 1984. These dramatic changes in policies and in farmers' responses marked the beginning of sustained expansion in rural industry. Between 1980 and 1993, rural industrial output value grew at nearly 35 percent per year (ZGTJNJ, 1995). By 1994, nearly 20 million non-state rural enterprises employed 113,296,984 peasants (24 percent of all rural labor), produced one half of the national industrial output value, paid one quarter of national taxes, and brought in about one third of the nation's foreign exchange from exports (The China Handbook, 122). The share of industrial output produced by rural industry is a feature unique to China's development, when compared to the development experiences of other countries

2.3 Rural Labor Market in Change

The fundamental changes in the distribution of the labor force have been the main feature of China's rural labor market since the reform. Between 1978 and 2000, the rural labor force grew by 2.6 percent per annum, from 306.4 to 479.6 million, while the workers in rural non-agricultural activities increased by about 27 percent per annum, from 21.8 to 151.6 million. About 75 percent of the rural labor supply increment was absorbed in the non-agricultural sector, where a majority of the total went to the Township and Village Enterprises (see Table 2-1)[4]. Non-farm employment has been an important contributor to sustained income growth since the initial rural reforms in organizations and prices. It is worthwhile to quote the succinct appraisal of the *1996 World Development Report (page20-21)*

Despite the industrialization efforts of the 1950s and 1960s, China was very poor and largely rural at the start of its reform. Agriculture employed 71 percent of the work force and was heavily taxed to support industry…….Because the agricultural sector had been so heavily repressed, freeing it up had immediate payoffs. Between 1981 and 1984 agriculture grew in average by 10 percent a year, largely because the shift to family farming improved incentives. This allowed for the reallocation of surplus agricultural labor to new rural industries, which generated 100million new jobs between 1978 and 1994 and encouraged further reform.

Some research has revealed that most of the development has occurred in the coastal provinces while inland areas still rely on agriculture and do not enjoy the high incomes of their more industrialized coastal counterparts (Lohmar, Rozelle and Zhao, 2000). Growth in rural industry initially provided off-farm employment opportunities primarily for local residents; the continuing success of rural enterprises has begun to open up local labor and managerial markets, which stimulated a fast growing rural-to-rural labor movement.

China has used a household registration system for tax collection and social control purposes for over 2000 years; but its current importance stems from its formal adoption by the Chinese government in 1958, with the issuing of Regulations on Household Registration of the PRC. According to the regulation, Hukou (type of

4 Yang 2003, China's Labor Market

household registration status) designates a person’s legal place of residence and work at the time of his or her birth based as the locality of the mother’s registration. Hukou is categorized as agricultural Hukou and non-agricultural Hukou. Possession of the appropriate Hukou determines one’s access to various amenities and social services such as health care, schooling, and until recently, rationed or subsidized food products, which were provided only to urban residents. Therefore, although the rural labor force had strong desires to seek employment opportunities with better pay in cities, they had to overcome legal barriers to working in cities.

Because of the inefficiency associated with labor misallocation, the Hukou system has been modified in recent years to permit more flexible labor reallocation between rural and urban markets. In 1988, a major policy reform was introduced to permit farmers to work in cities, provided they could secure their own staples. This regulation relaxed the controls over rural-urban migration and gave rural workers opportunities to work temporarily in cities. In contrast, under the old system, a college education (not even marriage) was the only legitimate channel to access urban registration.

In the early 1990s, the end of food rationing further reduced the costs of living for temporary rural migrants in cities because they no longer had to bring food with them from the countryside. They could purchase food directly without securing rationing coupons. 1998, the Ministry of Public Security issued another regulation loosening the control of Hukou registration—those who moved to join their parents, spouses and children in cities could also receive urban registration.

The reform of the Hukou system is still incomplete and its progress varies across provinces and even cities. In general, local situations fall into one of the three models: (1)

in over 20,000 small towns, applicants may receive local registration if they have a permanent source of living and housing in the locality, (2) in many medium-size cities, including a few provincial capitals, requirements for gaining Hukou status have been significantly reduced; some just require a long-term work contract, and (3) in a few mega-cities such as Beijing and Shanghai, obtaining Hukou remains very difficult for outsiders.

Even so, Chinese rural people are fully responding to the relaxation of long-standing controls over rural-to-urban migration. A commonly cited figure puts the number of rural migrants residing in urban areas at 50 million in the mid 1990's[5]. Due to the long-standing policy of restricting migration from rural to urban areas, a significant urban-rural income gap developed, providing rural people a strong incentive to migrate to urban areas. The per capita income in the urban area was 3.09 times that in the rural areas in 1980 and 3.27 in 1993[6].

Given the distortions in the factor markets before the reforms, the subsequent labor movements from the low productivity agricultural sector to the higher productivity non-agricultural sector became a major source of economic growth in China in the post reform period. Estimates by the World Bank (1997) suggest that labor mobility contributed 1.5 percentage points to the annual GDP growth rate of 9.4 percent over the period between 1978 and 1995, which is 16 percent of the GDP growth of that period.

[4.]Yaohui Zhao, Leaving the Countryside: Rural-to-urban Migration Decisions in China, AEA Papers and Proceedings, 281-286, May 1999

[6] From National Bureau of Statistics Research Group, A Study on the Urban-Rural Income Gap, Economic Research, 1994, Issue 4, 34-45

The preceding description shows that there are three forms of off-farm employment for Chinese farmers: (1) TVE employment, (2) private and individual sideline businesses, and (3) rural to urban migration and rural to rural migration. Despite rapid economic growth, it is commonly believed that significant institutional barriers still exist in China’s rural economy and dampen off-farm labor market participation. Under the HRS, land is still collectively owned. Households have only land-use rights. Land holdings are subject to periodic readjustment in response to households’ changing worker to dependent ratios. Upon permanently leaving agriculture, farmers have to return the land to local authorities and consequently give up a stream of potential land earnings in the future. Moreover, Chinese farm households are under obligation to deliver a part of their grain output to the State at prices specified by the government. Farm households are thus restricted to allocate labor to alternate employment. Land tenure arrangements and mandatory marketing delivery quotas have been accused of retaining more labor than is optimal in agriculture to fulfill their obligations (Cook 1999, Benjamin and Brandt 2002). Rural-to-urban migration has been shown to be circular and temporary (Zhao, 1999).

Table 2-1 Rural Labor Force Distributions Among Economic Activities 1978- 2000 (millions)

Year	*Total Rural Laborers*	*Agricultural Laborers*	*Nonagricultural Laborers (total)*	*Nonagricultural TVE Workers*
1978	306.4	284.6	21.8	22.2
1979	310.2	278.3	31.9	23.8
1980	318.4	298.1	20.3	25.4
1981	326.7	289.8	36.9	25.9
1982	338.7	300.6	38.1	27.7
1983	346.9	303.5	43.3	29.3
1984	359.7	300.8	58.9	49.2
1985	370.7	303.5	76.2	67.2
1986	379.9	304.7	75.2	77
1987	390.0	308.7	81.3	85.7
1988	400.7	314.6	86.1	93
1989	409.4	324.4	85.0	91.3
1990	420.1	333.4	86.7	90.2
1991	430.9	341.9	89.0	93.7
1992	438.0	340.4	97.6	103.3
1993	442.6	332.6	110.0	120.6
1994	446.5	326.9	119.6	117.6
1995	450.4	323.3	127.1	125.5
1996	452.9	322.6	130.3	131.7
1997	459.6	324.3	135.3	127.7
1998	464.3	326.3	138	122.7
1999	469	329.1	139.9	NA
2000	479.6	328.0	151.6	NA

NA=Not Available

Sources: Yang 2003, China's Labor Market, Table 1

Chapter 3

Literature Review

An abundant literature has evolved that investigates the determinants of farm household involvement in non-farm labor markets in the USA and in other developed countries. Research to assess Chinese rural labor markets and studies on multiple-job holding by Chinese farmers has just surged since the early 1990's. Due to different stages of economic development, it is not surprising to notice the dramatic differences in Chinese rural labor markets and their American counterparts. For example, most studies about off-farm labor markets in the USA have found education to be a key determinant of labor supply and income distribution. The most unusual result arising from the analysis of the Chinese rural labor supply is the insignificant effect of education, which suggests that labor allocation is not market-based yet in certain parts of rural China. Reviewing literature about the USA and other developed countries help to perceive the difference, as well as shed light on the research method of this dissertation. Section 3.1 reviews some research that have been conducted in the USA and other developed countries. Section 3.2 reviews some research that has been performed about Chinese rural labor markets.

3.1 Literature about the USA

Fuguitt (1959) used the "push-pull" hypothesis[7] of migration theory to explain off-farm employment. He conducted multiple regression analysis to test the hypothesis that off-farm employment is directly related to off-farm opportunities and negatively related to farming opportunities based on his Wisconsin data. The hypothesis was strongly supported by his empirical results for all farms, and for commercial farms analyzed separately.

Lee (1965) demonstrated that "the decision by a farm operator to allocate part of his resources (mainly labor) to non-farm employment may be both consistent and rational with the goals of maximizing family income and making efficient use of farm and family resources." Polzin and MacDonald (1971) strengthened Lee's explanation, showing that farm households allocated their labor resources between farming and off-farm employment to maximize their labor returns.

Huffman (1973a) initiated a study of multiple job holdings by analyzing the off-farm labor supply of farm operators. He also used the 1964 Census of Agriculture, which covered 276 counties in three states: Iowa, North Carolina, and Oklahoma. A theoretical model of labor supply was used to derive an off-farm labor supply equation, which indicated the change in the number of days worked at off-farm employment as a function of changes in non-farm earnings, the wage rates of the farm operators and their spouses, and several other household behavior variables. The coefficients of the explanatory

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[7] A migration theory that suggests that circumstances at the place of origin (such as poverty and unemployment) repel or push people out of that place to other places that exert a positive attraction or pull (such as a high standard of living or job opportunities).

variables had the expected signs in general and high explanatory power. Mishra (1996) pointed out that Huffman's study was deficient in two ways. First, the theoretical model could not be used to explore the effects of a change in returns of labor in farming work on off-farm labor supply, because Huffman assumed that the farm operator received only one wage—the off-farm wage. Second, Huffman formulated the theoretical model on the behavior of individual households, whereas he used aggregated data. OLS estimation of labor supply can lead to a certain degree of aggregation bias in comparison with fitting the same equation to individual cross section data.

Sexton (1975) used individual farm operator data to estimate the off-farm labor supply. He derived the supply model from household behavior theory. Two different surveys, one from the southeastern part of the United States and the other from Illinois, were utilized. Spouses were included in the household model. Off-farm work hours were estimated by OLS, and wage rates, farm hours worked and family composition variables were used as explanatory variables. The operator's farming hours was the only farm characteristic used in the study. The results showed that the number of hours worked off the farm was negatively related to age and schooling level. The spouses' wage rate and non-labor income had little effect on the farm operators' decision about the number of off-farm working hours.

Barros (1976) employed logit estimation procedures to estimate the asking and offered wage rates equation of the off-farm work decision, which helped him to estimate the off-farm labor supply function of farm operators. Based on the earlier studies of Lee (1965) and Polzin and Macdonald (1971), Huffman (1976) extended research on the determinants of total labor supply and off-farm labor supply. He showed how the labor supply responds to changes in household non-earnings income, farm and off-farm wage rates, commuting distance to off farm work, and household environment variables. Farm and off-farm wage rates and commuting distance to off farm work significantly affected both total and off-farm labor supply. The non-earnings income elasticity of total and off-farm labor supply was positive. Farm household characteristics such as husband's and wife's schooling level, husband's age, number of young children, number of older children, other adults in the household and race had strong effects on the number of days worked off farm.

Sumner (1978) used the same data as Barros and Sexton to analyze off-farm labor supply by comparing the marginal values of time spent in different activities. He identified factors to show that farm operators could perceive the value of time spent in farming, off-farm jobs, and non-work activities. Sumner's empirical model considered the participation question and the possibilities of sample selection bias that might arise in the OLS wage and hours equation, though no statistical evidence of such bias was detected. Sumner ignored the issue of simultaneity of farm and off-farm hours with each other and other farm factors.

Bollman (1979) suggested that the farm operator's total labor supply (total of farm labor and off-farm labor supply) is a function of the price of the consumption good, the price of operator's leisure, and non-earned income. He also suggested that the farm operator's total labor demand function is kinked. An individual farmer's demand for farm work is a function of the price of farm labor, the price of other inputs, the price of farm output, and demand for off-farm work is a function of the expected off-farm wage, which is a function of the operator's skill and commuting cost. The operator is assumed to be indifferent between farm and off-farm work if the marginal returns to labor are the same. When the price of the operator's labor farm work exceeds the expected off-farm wage, the farm operator's farm labor demand curve is downward sloping. The number of hours worked is determined by the intersection of the supply and demand curves.

Huffman (1980) used a family utility function and budget constraint to study off-farm labor supply by farm operators in Oklahoma, North Carolina and Iowa. Household utility is assumed to be a function of leisure and consumption, given a member's age, educational level and household size. The utility maximization is assumed to face three constraints: (1) time endowments to be allocated among farming, off-farm employment and leisure; (2) household income including net farm income, off-farm income and other household income; and (3) farm output. The second constraint limits the household's consumption level and the third constraint limits the household's budget size. Consequently, the total labor supply is a function of the off-farm wage rate, the price of farm output, the price of inputs, the price of consumption, household income, household size, age, education, extension and time endowments. The results showed that farmers' off-farm labor supply is positively correlated with farmer's education and extension input. Results also suggested that farmers with higher education levels reallocated their labor resources from farm work to off-farm work faster than those with lower education level.

Kimhi and Lee (1996) applied a minimum distance estimator to a system of simultaneous equations describing farm men's and women's on-farm and off-farm joint labor supply decisions. The data set utilized is from Moshav, Israel, which only included qualitative ordered realizations of the dependent variables. The main finding is that an increase in the husband's farm labor supply leads to a decrease in the off-farm labor supply of both the husband and the wife. An increase in the husband's off-farm labor supply also leads to a decrease in the wife's off-farm labor supply. On the other hand, changes in the wife's farm or off-farm labor supply have no statistical significance.

Mishra and Goodwin (1996) used a simultaneous-equations Tobit estimator to analyze joint off-farm labor supply decisions of operators and their spouses in Kansas. They confirmed that off-farm labor supply is positively related to the riskiness of farm incomes and off-farm working experiences. Farm-specific educational activities, small children, and government support tend to negatively affect off-farm labor supply.

Goodwin and Holt (2002) evaluated determinants of off-farm labor market participation among agrarian households in transition Bulgaria. They used a semi-parametric least squares estimator to model the extent of labor market participation, which yields consistent estimates without strong distributional assumptions. Therefore, they avoided possible misspecification of the distribution inherent in maximum likelihood estimation and possible misleading results. They found that labor supply of Bulgarian agricultural households is positively affected by factors such as education and work experience, similar to what is commonly observed in developed market economies, and social benefit programs providing monetary or in-kind support payments significantly decrease off-farm work.

3.2 Literature about China

Burkett and Putterman (1993) estimated a labor supply model under the old collective farming system. Their main findings were that wage rate (the value of a work point) had no effect on individuals' labor supply and that individuals tended to over-supply labor in order to maximize their work points and their share of the collective payment under the terms of the work point system.

No disagreement arises about the absence of a labor market during the pre-reform period, but there are sharp differences of opinion regarding whether a transition to a full-blown labor market has begun to occur. Some researchers believe that significant barriers still exist and hinder rural labor allocation moving towards the market. In contrast, others believe that rural labor markets have emerged and are spearheading China's drive towards modernization.

Parish, Zhe and Li (1995) suggested two indicators of an emerging labor market to evaluate farmers' chances of securing non-farm jobs using market channels. The first is rewards to administrative connections. The second is returns to human capital, including both education and accumulated work experience. The dataset used is a 1993 study of ten counties scattered widely throughout the eastern two-thirds of China. The results exhibit considerable local variation. Rural labor markets have begun to emerge near big cities and along the coast and in a few exceptional places such as the Muslim minority area where long-distance commerce has a special historical tradition. Spillover effects have occurred as some rapid-growth, high labor-demand areas start to exhaust their own labor and attract temporary immigrants. In the high labor demand cores, administrative connections have less effect on people's off-farm jobs and income. Education increases a farmer's (especially a female's) chance of getting a non-farm job though income returns to education are generally modest. Women have higher education returns than men; although women remain more in farming than men.

Yang (1997) inspected the effects of current rural land arrangements on labor mobility. He developed a farm household model that considers part-time farming and decisions to permanently leave agriculture. The study suggests that the lack of land markets imposes a loss in land values on rural households with permanent moves, resulting in mis-allocation of labor between agriculture and non-agricultural activities. Yang called for further land reforms to define property rights.

Yao (1998) tested the competitiveness of the labor market in semi-industrialized Ninxian County in eastern China's Zhejiang province, and studied the wage determination in its TVEs. The rural area in Zhejiang province is considered to be the most advanced rural area in China. Yao identified two forms of non-price rationing of industrial jobs. One is called entrance rationing which means that some people are rationed out of the industrial sector while current employees can choose to work as many days as they wish. The other is called time rationing under which people's industrial working days are being restricted but the entry to the industrial sector is not impeded. He extended Roy's (1951) income maximization model to study the case of simultaneous employment across sectors and the unobservability of wages in the agricultural sector. The joint employment across sectors is used to estimate a structural industrial labor supply equation by which the parameters in agricultural sector are derived. Different structural restrictions imposed on the competitive model, entrance rationing, and time rationing are used to identify parameters. The results showed that time rationing is prevalent in the county and the competitive model is rejected. Gender and government interventions are found to be the only factors strongly differentiating industrial wages. A worker in a village where employment and wage determination are controlled directly by the government earns 29 percent more than that in another village. Education and experience have little effect on wage determination.

Cook (1999) investigated the existence and consequences of surplus labor at the household level, using 1990 survey data from Zouping County in Shandong province. Based on estimation of household production functions, the labor returns in household agriculture and non-agriculture production are calculated, and determinants of labor allocation and productivity are explored. Marginal returns to labor for non-agricultural activities are shown to be higher than those for agricultural activities in rural China. Contemporary Chinese agriculture is characterized by a surplus labor supply, which means that agricultural output will not be reduced with the surplus labor transferred out of agriculture. A rural labor surplus supply exists at the household level and affects labor allocation decisions. In addition, the results revealed higher returns to education in nonagricultural activities, suggesting that market forces play a role in labor allocation outside agriculture. However, political connections are found to be critical in resource allocation. Cook suggested that institutional barriers such as the land tenure arrangements, the mandatory crop quota system, the household registration system and the lack of an agricultural labor market in many regions hinder household labor allocation and retain excess labor in agriculture.

Rozelle, Taylor and DeBrauw (1999) used the New Economics of Labor Migration to trace the linkages among migration, remittance, and agricultural productivity. They constructed migration as a function of networks and household human-capital variables. Land availability and quality, household physical capital and demographic variables, wealth (measured as the value of all non-productive assets), and tenure security are hypothesized to affect productivity. They found that high wealth increases yields and wealthy households are less likely to participate in migration, and migration has a significant negative effect on yields, which is partly offset by access to capital through increased remittances. Their results suggest that there is no existence of labor surplus at the household level since temporary migration depressed yields, contradicting Cook's finding.

Meng (2000) followed the empirical model of Burkett and Putterman (1993) to investigate if China's rural labor supply responds to market signals post reform. The data set used is from a 1994-5 sample survey of about 1,000 rural households of China's five provinces, Guangdong, Jilin, Jiangxi, Sichuan and Shangdong. The dependent variable is defined as household average labor workdays. The study found that the rural labor supply responded in normal ways to market signals and that the labor supply curve was backward bending. A 1 Yuan increase in the daily wage rate initially brings 3 days increase of annual labor supply. When the daily wage rate reaches a certain point (56 Yuan), a further increase in wages will lead to less labor supply. In his dataset, the average wage rate is about 8.4 Yuan, far from reaching the situation of a backward bending labor supply curve where the income effect dominates. Meng's analysis suggests that Chinese rural labor allocation has gradually switched towards a market-oriented system, "one in which income is determined according to labor productivity and labor supply responds to market signals".

Rozelle and Zhang (2000) stated that off-farm employment participation still differs by gender; men joined the off-farm labor force more often than women in all eight provinces covered in their data. However, opportunities for women to participate in off-farm employment have increased over the period between 1988 and 1995, and women have not suffered any measurable increase in wage discrimination.

DeBrauw, Huang and Rozelle (2002) extended the study on the emergence of labor markets by using rural household data collected in 2000 that contains 20-year employment histories for more than 2000 individuals from across China. The findings support the rapid increase in labor market activity over the whole period of the 1980s and 1990s. “Labor markets are acting consistently with an economy that is in transition from being dominated by agriculture to being dominated by other forms of production and consistently with a population that is becoming more urban.” They also analyzed the determinants of off-farm employment by using a fixed effects conditional logit estimator. The results showed that gender, age, and human capital (including education, training and experiences) strongly affect an individual’s participation in off-farm activity; household characteristics such as land area and wealth (measured as the value of durable assets) have no impact on off-farm labor participation.

Zhang, Huang and Rozelle (2002) focused on the role of education in off-farm employment. The data used were collected on the same households geographically narrowed over a 9-year period spanning the late 1980s and most of the 1990s. They estimated how education has affected off-farm employment participation and on-farm employment. They attempted to isolate the effect of education on wages. Returns to education are obtained by utilizing parameters from the wage equations. The primary finding is that the effect of education is increasingly important as the reforms proceed, suggesting that labor markets are maturing. Education increases the likelihood for individuals to participate in off-farm employment, and returns to education for off-farm and on-farm activities both are increasing. They also found that an individual's probability of working off farm rises when other members of a household have experience in off-farm labor markets. In addition, they argued that a number of non-market factors that were instrumental in off-farm employment participation and wage determination in the 1980s have disappeared in the 1990s. Their study is limited in that they did not consider some personal traits or institutions that could signify whether labor markets are improving or not.

In another of Rozelle's papers (with Chen and Huffman, 2003), they found an inverse relationship between farm size (measured in land area) and productivity in Chinese agriculture, which is partially or completely diminished when adjusted for land quality. Their results suggested that variation of productivity across households results from variations in land quality and that larger households have lower productivity. Based on the egalitarian principle of land allocation in China, Rozelle's farm size is equivalent to household size. They did not consider other household characteristics. For instance, each household makes their decisions about labor allocation, technology adoption, usage of fertilizer and other inputs, which are supposed to influence their productivity. Is it possible that larger households have lower productivity because they are more involved with off-farm employment? Furthermore, their productivity is measured as yield (grain output per unit of land) that is only one aspect of productivity. This dissertation will pursue a comprehensive measurement of farm household productivity.

Walder (2002) argued that rural households are receiving larger returns to household human capital with the progress of reforms. Nevertheless, there is no evidence implying a corresponding drop in returns to political position.

Benjamin and Brandt (2002) examined the impact of the combination of administrative land allocation and unevenly developed off-farm labor markets on farm efficiency. They revealed an inverse relationship between farm productivity and farm size, which is a signal that labor markets do not clear. They argued that considerable inefficiency in Chinese agriculture could be directly connected with imperfect factor markets and the limitations of land allocation administration. They advocated a system of secure property rights to facilitate the development of a decentralized land rental market. Kung (2002) demonstrated that the acceleration of off-farm labor market development induced the emergence of a nascent land rental market, drawing on an almost national representative farm survey.

Bowlus and Sicular (2003) tested for separability between household labor demand and supply using panel data (covering years 1990-1993) in Zouping county, Shandong province. They found that separability is rejected overall; indicating that in the early 1990s factor markets in Zouping remained underdeveloped. They also stated that separability holds where abundant employment opportunities exist in the wider township, showing that such employment improves competitive allocation within villages as well as the inter-village movement of resources.

Brauw (2003) used household survey data in Northeast China to investigate if Chinese women are taking over the farm. Some literature has shown that women tend to remain in farming while men are more likely to work off-farm. He maximized a household production function to obtain the male and female farming labor respectively. The measurement is established as the proportion of farm work being done by women. The finding suggested that women and men did almost the same amount of farm work on average in 2000. The average amount of farm work done by women decreased over time. He argued that women's off-farm labor participation has increased in the late 1990s, suggesting that off-farm labor markets have developed for both men and women during the 1990s.

Literature on the Chinese rural labor market exhibits vast contradictions and inconsistencies. Some research has shown that a rural labor market has emerged and is leading China's drive towards modernization; while other research suggests an embryonic rural labor market and argues that labor allocation is not yet market based. The contradiction and inconsistency is probably due to the magnitude of the questions, because transformations are happening at markedly different rates across the country. However, most studies considered only part of the labor market and focused on only a subset of questions about labor market performance at different times and in different places and in that sense lack comparability.

Chapter 4

Farming Efficiency and the Determinants of Multiple Job Holding

4.1 Introduction

As the market-oriented reform proceeds, Chinese farmers are having more opportunities in participating in the off-farm labor market. Off-farm work has increasingly become a prominent determinant of farm household income. In the case of multiple job holdings, farmers will compare their options and allocate their time so as to maximize their total utility, which implies equalizing marginal returns to labor in alternative jobs and in the consumption of leisure. An important question in this regard is that how off-farm employment is related to farm households' farm efficiency? On one hand, more time spent in off-farm work implies less effort being focused on the farm work. Smith (2002) of the USDA posed the interesting question "Does Off-Farm Work Hinder 'Smart' Farming?" in a recent paper. She noted that the increased reliance on off-farm employment may have implied less attention to issues important to farm productivity, such as adoption of best management practices, integrated pest management, and precision farming. Smith argued that such practices, which she termed "smart farming", are generally expected to lead to a reduction in variable production costs that should outweigh any losses in farm yields. However, to the extent that off-farm employment pulls away on-farm effort, adoption of such technologies may be inhibited, and less efficient farming may result.

Goodwin and Mishra (2004) attempted to evaluate the relationship between off-farm work and farming efficiency. They used survey data from USDA's 2001 National Agricultural Statistics Service (NASS) Agricultural Resource Management Survey (ARMS) project, which covered 7,699 farms. Their studies confirmed an inverse relationship between farming efficiency and off-farm labor supply, showing off-farm labor supply and farming efficiency are jointly determined for farming households in the USA.

What are the factors affecting Chinese rural households' off-farm labor supply? How does the operation of the farm affect the off-farm labor supply? How does off-farm work by the operator affect the operation and organization of the farm? This chapter explores the determinants of farmers' off-farm labor supply and investigates the relationship of off-farm labor supply and farming efficiency for Chinese agricultural households. Section 4.2 presents the theoretical model. Section 4.3 presents the econometric methodology. Section 4.4 discusses data and variables used for the empirical study. Estimation results are reported and discussed in Section 4.5. Section 4.6 summarizes the contribution of this study.

4.2 Theoretical Model and Its Implications

As mentioned in Chapter 1, the agricultural household model provides a unifying microeconomic framework for understanding the agricultural households' decisions on consumption, production, and time allocation. We will present the basic structure of the model, which serves as the base for the theoretical discussion. The presentation will be based mainly on the theme of time allocation.

If agents face multiple job choices, they will compare options and allocate their labor time to maximize total utility, which implies equalizing marginal returns to labor in alternative jobs and in the consumption of leisure. More time spent in one job generally implies less in others. For farm operators with multiple job holdings, the increasing significance of off-farm work may imply less labor effort being supplied to farm work. The scope of opportunities for an individual farmer is possibly determined by his or her stock of talents and expertise. Generally, farmers' stock of human capital and thus their off-farm marginal wage may be reflected in their formal education, age, and experiences working in off-farm activities. Other operator characteristics such as sex may play an important role in explaining the observed allocation of their labor effort in an imperfect labor market. When individual household members are considered, important differences in the relative opportunities in farm and off-farm employment for operators and their spouses may exist. For example, a wife may have fewer opportunities for off-farm employment if the household has young children.

Assume income-generating options exist for each farm operator in agriculture (supplying F hours of labor to farming) and through off-farm employment (supplying M hours of labor to the off-farm market). Under conditions of perfect information, we assume that the farm operator maximizes a utility function having leisure (l) and the consumption good q as its arguments:

(4-1) $U = U(q, l, \kappa)$

subject to:

(4-2) $pq + r^{'}X = wM + P_f Q(X, K, F) + A$;

(4-3) $T = F + l + M, F > 0, l \geq 0, M \geq 0$;

Where q=consumption good

l =leisure time

κ = household characteristics

w = the off-farm wage rate

F = hours of farm labor supplied

M= hours of off-farm labor supplied

T = total endowment of time

p = the price of consumption goods

P_f = the price of farm output

Q (.) = farm output

r = a column vector of prices of other farm inputs

X = a column vector of other input quantities

A = non-labor income.

The utility of the household is determined by leisure time and consumption of the goods. The utility function is assumed to be quasi-concave in these variables and twice continuously differentiable. We allow the utility function to vary according to operator characteristics, which are represented by κ. The household faces two restrictions. The first is the budget constraint (4-2): the level of consumption is set by the sum of farm income, off-farm income and exogenous non-labor income. Farm output is produced according to the production function Q (.) using farm labor (F), human capital (K), and other farm inputs (X). The model assumes that the marginal utilities of leisure and the consumption good approach infinity as consumption approaches zero, thus ensuring that positive levels of leisure and the consumption good are always consumed[1]. The second is the time constraint (4-3): there is a fixed amount of time, which is allocated among leisure time, farm work and off-farm work. The model assumes that the marginal productivity of farm labor goes to infinity as farm labor approaches zero so that some time is always spent on farm (F>0), and optimal hours of off-farm work may be zero (M≥0). The modeling takes account of these inequality constraints on working hours, which are important for valid analysis of farming efficiency and for proper empirical specification of off-farm labor supply function.

Under the assumption of the differentiable utility function, the optimality condition can be stated with the help of the Langrangian function:

$$(4\text{-}4)\quad L = U(q,l,k) + \lambda[wM + P_f Q(X,K,F) + A - pq - r^{'}X] + \gamma(T - F - l - M)$$

The Kuhn-Tucker first-order conditions for maximizing the utility function subject to the income, time, and nonnegativity constraints are:

$$(4\text{-}5)\quad \frac{\partial L}{\partial X} = P_f Q_{Xn} - r_n = 0, \quad \text{for inputs n=1,…N}$$

[1] This assumption is common in analysis of labor allocation and eliminates the need for the restrictions ensuring positive levels of L. It is also sometimes assumed (see, for example, Huffman and Lange (1989)) that the marginal productivity of farm labor approaches infinity as the utilization of labor falls to zero, thus ensuring positive on-farm work levels. Note also that, without loss of generality, we make the simplifying assumptions that the marginal productivity of other inputs X goes to infinity as input use goes to zero, such that a positive level of X will always be applied.

(4-6) $\frac{\partial L}{\partial M} = \lambda\omega - \gamma \leq 0, \quad M(\lambda\omega - \gamma) = 0,$

(4-7) $\frac{\partial L}{\partial F} = \lambda P_f Q_F - \gamma \leq 0, \quad F(\lambda P_f Q_F - \gamma) = 0,$

(4-8) $\frac{\partial L}{\partial q} = U_q - \lambda p = 0$, and $\frac{\partial L}{\partial l} = U_l - \gamma = 0$,

where λ and γ represent Lagrange multipliers for the household's income and time allocation. If an interior solution occurs (implying a non-zero supply of labor to off-farm employment), the first portions of equations (4-6) and (4-7) hold as equalities and can be solved to yield the following familiar conditions:

(4-9) $\frac{U_q}{U_l} = \frac{p}{w}$

which implies that the marginal rate of substitution between leisure and the consumption good is equal to the ratio of the consumption good price to the wage rate, or that the value of the marginal product of farm labor is equal to the off-farm wage rate.

(4-10) $P_f Q_F = w$,

Corner solutions are implied if off-farm labor supply is zero (on-farm labor supply is always positive for the valid analysis of farming efficiency). If we hold the total amount of labor supplied constant, an increase in the price of farm output or an increase in on-farm labor productivity would be expected to result in more labor being supplied to the farm and less to off-farm activities. Likewise, an increase in the off-farm wage rate would result in a lower level of farm employment.[2]

Because of imperfections of markets, especially imperfect information resulting in uncertainties and risks, farmers' decisions on labor supply allocation are not achieved automatically by the 'invisible hand' of markets, but are burdened by transaction costs such as search, travel, communication and etc. Transaction costs incurred in finding off-farm work reduce effective wages earned from off-farm work and therefore reduce the amount of time spent working off-farm, while increasing time spent farming. Conversely, a reduction in transaction costs raises the amount of time a farmer spends working off-farm and decreases farm labor supply. Taking transaction costs into account, a farmer's labor supply is allocated between farm and off-farm work such that the marginal value of farm labor equals the off-farm wage net of transaction costs, which can be stated as $w(1-t)$, where t represents transaction costs converted to an hourly basis.

4.3 Econometric Methodology

The goal of the analysis lies in providing estimates of descriptive off-farm labor supply decisions rather than explicit estimation of a structural model of labor supply. Thus, we adopt a simple reduced form modeling approach and relate off-farm labor supply decisions and on-farm efficiency measures to observable farm and operator characteristics reflected in the determinants of wages, prices, and characteristics of the production and utility functions.

[2] Under more general conditions, the impact of such changes on overall labor supply depends upon competing income and substitution effects.

Our model consists of two reduced form equations, representing the off-farm labor supply of farm operators and their farming efficiency. We measure farming efficiency by the ratio of gross farm income to variable costs. We don't include fixed costs because fixed costs don't change with the change of on-farm labor supply (which is caused by the change of off-farm labor supply).

Farming efficiency is assumed to depend on exogenous farm-specific characteristics such as the farm size and soil characteristics; exogenous location characteristics such as village policy about land transfer and land readjustment and the human capital of the operator. We are interested in testing if years of formal education are pertinent to the efficiency of farming on an individual operation. Total annual hours worked off the farm is included as the measure of participation in off-farm labor markets, which is expected to be endogenous to farming efficiency since efficiency is a factor determining the implicit wage for on-farm labor. The model predicts the effect of off-farm labor supply on farming efficiency to be negative. Off-farm activities pull labor force and farmers' attention away from farm work, which has negative effects on farming efficiency, as remarked by Smith and showed by Goodwin and Mishra in the case of American farmers.

The second equation is a standard, reduced-form labor supply equation relating hours of off-farm work to variables pertinent to wages, farming efficiency, village, farm and operator characteristics potentially relevant to off-farm work opportunities and the costs associated with off-farm work. At the individual level of information, the operator is either working off the farm or is not working off the farm. The corner solution implied in the off-farm labor supply decision raises the issue of censoring or selection issues. The censoring is recognized through the adoption of the Tobit model, which has been popularly used to estimate labor supply equations with work hours as the dependent variable because hours are clustered at zero for non-workers. The model under consideration is

(4-11) $Y_i^* = X_i \beta + U_i$

where

(4-12) $Y_i = Y_i^*$ if $Y_i^* > 0$

$Y_i = 0$ otherwise

Y_i is hours of off-farm work. Y_i^* is called a "latent" variable, which is unobserved if $Y_i^* \leq 0$. X_i represents independent variables which are observed in every case. U_i is the error term with $U_i \sim IN(0, \sigma^2)$.

We also employ the method of Smith and Blundell to test the endogeneity of farming efficiency and off-farm labor supply to each other. Smith and Blundell have shown that an efficient test for endogeneity of right-hand side variables can be obtained by including residuals from a reduced form equation for the suspected endogenous variable as regressors and testing their statistical significance. The equations were estimated jointly using instrumental variable techniques, allowing for the joint determination of farming efficiency and off-farm labor supply.

One econometric concern emerging in this strategy is that the first stage reduced form equation estimation causes the instrumented regressor (i.e. farming efficiency) to misrepresent its true variance, which would be propagated to the second stage. We applied a bootstrap to address this problem. "The bootstrap variance is generally more efficient as a statistical estimator of the unknown true variance.[3]" First, I sample with replacement from the data. Then I reestimate the full sequential model for each bootstrap sample and repeat the procedure for a total of 500 replicates.

4.4 Data and Variables

The data used for estimation is from the World Bank's North and Northeast China Living Standard Survey, which we talked about in chapter 1 (1.3). The original sample consists of 787 farm families. We excluded those families that participated in neither agricultural production nor off-farm activities in 1994 (It might be the problem of data reporting). The model was applied to a sample of 747 operators. Some observations were dropped because of missing data for some of the variables; consequently 551 observations were used in the estimation. Among 747 households, 494 (66.13%) household heads enter off-farm activities, out of which 486 are male and 8 are female; the majority of operators (717) are male, 30 household heads are female. Table 4-1 describes the structure of off-farm job holding by sex.

Definitions and summary statistics for the variables considered in our empirical analysis are described in Table 4-2. In the off-farm labor supply estimation, the dependent variable is defined as the annual off-farm working hours. Some of the explanatory factors merit special discussion.

[3] The comment and this paragraph draw on the book by Efron, Bradley and Tibshirani (1993).

Individual characteristics

Human capital may be the most important individual characteristics affecting the off-farm labor supply. Farm operators build human capital through investments in education, experience and vocational training. The effects of human capital on the off-farm labor supply include both direct and indirect effects. Human capital enhances an individual's performance in farming activities, thereby increasing the shadow value of labor. A better-educated person or a person that received off-farm training has better opportunities in the off-farm labor market. We use years of formal schooling and months of nonfarm vocational training as indicators of an individual's stock of human capital, which are expected to increase his off-farm labor supply. The empirical information for both on-farm and off-farm experiences are not available in our cross section survey data.

Age is an important demographic indicator of the preferences of individuals, such that older individuals may have different views and attitudes about employment. In the estimation of off-farm labor supply, we include age of the operator. In the estimation of farming efficiency, we include the average age of family members who worked on the farm in the year.

Family characteristics

Family characteristics, especially the presence of young children, have been shown to have important effects on off-farm labor supply. As elsewhere, traditional Chinese farming families tend to place homemaking and childcare responsibilities on women. Therefore we expect the presence and number of children will be inversely related to the hours worked off-farm by farmwomen. The effects of children on the labor supply by men are uncertain.

Children may require childcare time by the husband. On the other hand, there may be further pressure for additional income for larger families.

Household size has been shown to be an important variable in many studies in other countries. Usually, a larger household reflects advantages in both farm labor and off-farm labor supply. Based on the land allocation system in China, household size is highly correlated with household farmland area. As one of the most important elements of agricultural production, farmland area will be included. In the estimation of farming efficiency, we use FARMERR (the ratio of number of family members worked on farm in 1994 to the household size) instead of household size to reduce the possibility of collinearity. We also include MALEFARMERR (the ratio of the number of male farming workers to the number of farming workers in the family) to test if male farmers contribute more to farm work.

Since both husband and wife may supply labor to the off-farm markets, their labor allocation decisions may be joint and simultaneous. How is one farmer's off-farm labor supply affected by his spouse's decision? Also if adult children work off-farm, does this have influence on their parents' labor supply? Answers to those questions will be quested in Chapter 5. We will skip the characteristics of the spouse in this chapter.

Farm production and financial characteristics

Different variables have been used as production characteristics to estimate off-farm labor supply function. Huffman (1980) estimated a production function and used the predicted values as an explanatory variable. Streeter and Saupe (1986) estimated the farm revenue function and included predicted values in the labor-supply function. Here, we are interested in testing the relationship of farm operator's off-farm labor supply and the household's farming efficiency. As mentioned earlier, our measure of farming efficiency is given by the ratio of gross farm income over total variable costs. A more structured measure of farming efficiency will be pursued in chapter 6. The model expects an inverse relationship between farming efficiency and off-farm labor supply.

Total farmland owned by the family (FARMLAND) is included as a measurement of farm scale. The ratio of cropping area to total farmland (CROP_AREA), the ratio of area for vegetables and fruits to total farmland (NONCROP_AREA), and the ratio of income from livestock to the ratio of income from cropping (LIVESTOCK_CROP) are used to measure the effects of different farm activities, which affect off-farm labor supply through both time and budget constraints. HIGH (LOW) are the ratios of high (low) quality crop growing area of total cultivated area of the household. They are included to adjust for land quality. MODERNTOOL is defined as the monetary worth of modern farming tools such as a tractor and pump, mechanical plough etc, which is expected to increase farming efficiency.

CONTRACT is a dummy variable having a value of one if the household has a procurement obligation at the government's fixed price. Among 747 households, 585 households were under a procurement obligation and 140 households were not (data for 22 households are missing). Whether the household has a contract or not depends on their land composition. The households that have no responsibility land and tenant land are not under a procurement obligation. There are five forms of land adjustment: 1. Private lot: a plot assigned during the commune era and early rural reform, by household or number of family members to farmers for farming not subject to adjustment, procurement and agricultural tax. 2. Ration land: land assigned by number of family members, following the rural reform, to farmers for farming primarily for meeting their household consumption of grain, subject to readjustment and agricultural tax but not subject to procurement and contribution to villages. 3. Responsibility land: land assigned by number of family members or workers, following the rural reform, to farmers for farming, subject to readjustment, procurement and agricultural tax, but not subject to village contribution. 4. Tenant Land: land leased to tenant farmers for farming, subject to procurement and agricultural tax in addition to village contribution and subject to occasional adjustment. 5. Auctioned tenant land: land of which tenure is auctioned by a village to participating tenant farmers for farming. The tenure is subject to a fee contribution to the village determined by auction in addition to procurement and agricultural tax, which would not be adjusted prior to expiration of the contract term of the tenure.

Family financial characteristics of the farm family are included to capture the effects of exogenous non-wage income on the consumption of leisure. If leisure is a normal good, higher levels of income from non-labor sources (NONLABORINCOME) would result in fewer hours of off-farm employment. The ratio of family debt to family assets (DEBT_ASSET) is used to capture the leverage effect. Farmers who are less financially restricted to invest in farming are expected to work fewer hours off-farm. Net worth of the family is also included.

Locational Characteristics

Locational characteristics for the farm family have been included to capture local labor market effects. A village functions as a society for the Chinese farmers, from where farmers get their kinship, friendship, information and opportunities. Farmers in the same village share land, natural resources and traditional advantages that their village has. A village's distance to a nearby urban area, and its transportation and communication conditions would strongly affect its development level of local nonagricultural activities and migration, which would further affect farmers' opportunities to enter the off-farm labor market. Farmers located in areas with better transportation are expected to be more active in the off-farm labor market. In our sample, each village has at least one nearby highway; 12 villages have a railway station nearby within 10 kilometers, 16 villages have a railway station nearby within 20 kilometers, 21 villages have a railway station nearby within 50 kilometers. The number of buses passing by daily and access to railway transportation will be considered to capture the effect of transportation options. NONAGLABOR_TOTALLABOR is the ratio of the labor force participating in nonagricultural activities to the total labor force in the village, which is included to measure the development level of the local off-farm labor market. All factors mentioned above also affect transaction costs, which empirically are not observed directly. Better transportation and a more active local off-farm labor market are expected to reduce transaction costs due to distance and information gathering.

FARMSERVICE is a dummy variable having a value of one if the village helps farmers with farming work such as irrigation and machine renting, which is expected to increase farming efficiency. ENTERPRISE is a dummy variable having a value of one if the village has at least one rural enterprise. Rural enterprises are supposed to grant more off-farm employment opportunities to local farmers. Out of 31 villages, 12 villages have rural enterprises. Information about readjusting land (LAND_INFO), local village's policy about land transfer (LAND_TRANSFER) and quota payment (QUOTA_PAY) are three dummy variables used to catch the effects of local village institutions. LAND_INFO has a value of one if farmers in the village are informed about when their land will be next readjusted. It is concerned with the household's land security. If farmers are uncertain about future land use rights, they have no incentives to make long-term improvements in the land (e.g. irrigation projects and other capital-intensive projects) that would increase grain yield. LAND_TRANSFER has a value of one if the village regulation allows for completely free land transfer. QUOTA_PAY has a value of one if the village authority allows quota to be fulfilled by cash. Completely free land transfer is allowed in 22 villages; 19 villages allow farmers to fill quota by cash; and farmers in 19 villages are informed about the next round of land readjustment. When farmers are allowed to transfer their land freely and pay grain quotas by cash, they have more freedom to leave farming and therefore have more active access to off-farm labor markets. LAND_TRANSFER and QUOTA_PAY are assumed to have negative effects on farming efficiency and positive effects on the supply of off-farm labor. More information about land adjustment is assumed to affect farmers' farming efficiency and therefore their labor allocation decision. These variables about local institutions are included to capture the effects of labor mobility restrictions due to policy and also the influence of transaction costs. Tight labor mobility restrictions raise transaction costs and vice versa.

4.5 Estimation Results and Discussions

Table 4-3 presents parameter estimates. First of all, contrary to the expectation of the theoretical model, I didn't find a significant inverse relationship between farming efficiency and off-farm labor supply for Chinese agricultural households. This is in contrast to Goodwin and Mishra's finding about American farmers. The coefficient of off-farm working hours has a positive sign, but it is neither economically nor statistically significant. It suggests that the operator's greater involvement in off-farm labor market has a trivial effect on the household's farming efficiency, which also suggests the existence of surplus labor supply in the household level farm work. Labor supply of the operator pulled away from farm work doesn't significantly affect household farming efficiency. China has about 2.5 agricultural laborers for every hectare of arable land. The Chinese Ministry of Agriculture estimates that rural China has 150 million surplus workers -- "China has a total of 480 million rural laborers, far outnumbering the actual need of 330 million by 150 million."[4].The consequence of surplus labor is that farming efficiency will not be reduced with the surplus labor transferred out of farm work. The negative relationship for American farmers in Goodwin's paper tells a totally different story in a developed economy where there is no surplus labor supply and involvement in off-farm activities competes with labor for agriculture.

Formal education shows no significant effect on farming efficiency. It may indicate that formal education doesn't help to improve farmers' practical farming techniques and scientific knowledge for agricultural production. Access to modern tools shows an

[4] "China: Surplus Rural Laborers Hit 150 Million." China Xinhua News Agency, April 8, 2004.

insignificant though positive effect. It reflects the fact that Chinese farming still remains in the traditional hand-planting and animal-plowing style, far from modern mechanization. It is consistent with some previous research results that the improvement of agricultural productivity in China so far mainly depends on institutional reform and increased use of fertilizers. To further improve farming efficiency, Chinese farmers need technology advances. The average age of farmers in the household shows a positive but insignificant effect on farming efficiency. The ratio of farm workers in the household shows a significant negative effect, indicating decreasing marginal productivity of farm labor. The ratio of male farmers to farm workers in the household has no significant effect.

Farmland area in the household is positively related to farming efficiency, indicating increasing marginal productivity of farmland. The small scale of Chinese farms, which is rooted in the scarcity of the land resource and the land allocation system, may explain this effect. The mean of farmland per household in our sample is 19.58 mu (3.13 acres/1.25hectares). The increasing marginal productivity of farmland suggests that the concentration of cultivated land in a smaller number of farms will increase farming efficiency, because larger farm can benefit from scale economies and technological innovations are best suited to larger scale farm operations. The ratio of high quality of land (HIGH) has no significant effect while the ratio of low quality of land (LOW) shows a negative effect and is marginal significant. Farming efficiency is highly improved if farmers are better informed about land readjustment, suggesting that farmers are more motivated by reduction of uncertainty. When farmers are certain about their future land use right, they are more willing to invest for land improvements. The policy of allowing filling grain quota by cash doesn't manifest significant effect. FARMSERVICE (if the village helps farmers with farming work such as irrigation and machine renting) largely increases farming efficiency.

Procurement obligation contract at the state's fixed price shows no significant influence on farming efficiency. To further explore the effect of market structure, we tried to use the share of total output sold in free markets and the share of total output sold to the government (They are not included in the final specification due to a large loss of observations caused by missing values). The finding is that the share of total output sold in the free market is negatively related with farming efficiency while the share of total output sold to the government is positively related to farming efficiency. It may seem to be counter intuitive that market-oriented reforms don't offer incentives to improve farming efficiency. However, this would make sense if government prices were higher than market prices. The compulsory quota system and the sale at ration prices to consumers were abolished in early 1993. In 1993 and 1994, grain prices increased sharply because of the reactions of farmers to inflation expectations and the reduction of grain cultivation in the coastal provinces where grain production was no longer to farmers' comparative advantage. Grain output for 1994 decreased to 445 million tons, down 2.5 percent from a year earlier. In 1994 per capita grain output was 5 percent lower than in 1984. Farmers' incentives for agricultural production deteriorated and resources were shifted to more profitable nonagricultural uses. While the role of the agricultural sector declined, farmers faced more opportunities for non-agricultural employment. For fear of food shortages, the central government reimposed the state compulsory quota system in 1994 and boosted procurement prices above world prices to induce farmers to increase grain production.

Table 4-3 also contains estimates of the labor supply equation. The coefficients don't directly represent marginal effects in light of the censoring. Greene (1999) shows that the marginal effects can be acquired by scaling the coefficients by the probability of noncensored observations (about 0.67 in this case)[5]. Table 4-4 reports the marginal effects of selected variables. Males are likely to supply much more labor to off-farm employment, suggesting a significant gender difference. Both education and vocational training are strongly and positively related to off-farm employment. One more year of education and one more month of vocational training induce respectively 89.53 and 15.41 more hours of off-farm labor supply. The substantial positive effects of human capital point to the existence of off-farm labor markets in the area. Age has a significant negative effect on off-farm labor supply. The marginal effect shows one-year younger in age results in 14.47 more hours of off-farm work. In our sample, the youngest farmer is 22 years old, and the correlation between age and education indicates that young people tend to be better educated. It is consistent with expectation that younger and better-educated farmers tend to have better opportunities in off-farm labor markets. It may also reflect differences in attitudes regarding work that are correlated with age.

FARMLAND and CROP_AREA are inversely correlated with total hours worked off-farm. If a household has a larger farm and cultivates a larger area for crop, the head may spend more time in the farm work and therefore less time in off-farm activities. Quality of land, NONCROP_AREA and LIVESTOCK_CROP demonstrate no significant effects on

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[5] Marginal effects are given by the product of the coefficient and the normal cdf, evaluated at a given observation (typically at the data means).

$$\partial E[y \mid x]/\partial x = \Phi(\beta' x / \delta)\beta = prob[noncencored]\beta$$

off-farm labor supply. Due to the long-term grain production emphasis policy, most Chinese agricultural households concentrate on crop cultivation; livestock and vegetables are mostly for family consumption. Large scale commercialized livestock operations and vegetable-fruit production are rare in our sample.

The ratio of DEBT_ASSET is not significant, suggesting that leverage effects do not have an important effect on off-farm labor supply. It may be explained by the imperfection of rural credit markets in China. There are state-owned agricultural banks, rural credit coops and other banks and foundations available in every town, but it is not a popular practice for Chinese farmers to loan to finance their farming investment due to huge transaction costs. One reason is that farmers don't own the land thus they have no mortgage. Nonlabor income is statistically insignificant, though it has a negative sign. It suggests the effect of nonlabor income on off-farm labor supply is negligible. Net worth shows a positive effect. The marginal effect is 0.006. Though it is small, it is both economically and statistically significant. It may suggest that the substitution effect dominates over the income effect for the labor supply of Chinese farm operators. Or it may reflect that farmers in a better economic situation are more likely to be involved with off-farm employment. The number of children under the age of 10 years in the household doesn't affect off-farm labor supply, which is not surprising since most household heads are male. We will inquire if the presence of young children affects women's off-farm work participation in chapter 5.

The policy about whether the land is transferable has a significant positive effect, indicating that more flexible land policy grants farmers more freedom to work off-farm. It implies that the current land situation in rural China creates labor mobility restrictions and inhibits farmer from entering off-farm labor markets. I considered both buses and railway transportation to capture the effect of better transportation, which doesn't show significant effect on farmers' off-farm labor supply. (Only BUSES is reported in the final specification since the two transportation means are correlated). The nonagricultural labor force ratio and the existence of rural enterprise have no significant effect on off-farm labor supply. This may be explained that rural enterprises in the area are not very well developed and more off-farm jobs are outside the village, in the towns or cities nearby. Only 36.2% of the off-farm jobs are in the village where the respondents live; 43.1% are in either the county or township seat; and 20.7% are in the cities. Farming efficiency has a slight negative effect on off-farm labor supply with a marginal effect of –202.24. This finding is consistent with the prediction of our conceptual model that a higher implicit farm wage (i.e., more efficiency) would tend to lower off-farm labor effort. The bootstrapped parameter estimates are reported in Table 4-5. They are qualitatively similar to the original estimation.

The Smith and Blundell test of endogeneity was rejected. It indicates that off-farm labor supply and on-farm efficiency for Chinese farm households are not jointly determined. Since there appears to be surplus labor supply in the agriculture, involvements with off-farm activities do not compete with labor for farm work. Surplus labor forces need to find their way to off-farm labor markets. I also estimated the farming efficiency function and the labor supply function separately. The results are reported in Table 4-6, which are qualitatively similar to the results of two-stage estimation.

There are a few more variables that I am interested in which are not included in our final specification either because of multicollinearity or because of a large loss of observations due to missing values. Major agricultural product growing countries across the world usually grant direct subsidies to their farmers instead of levying taxes. Statistics show that the per-hectare direct government subsidy was US $100 to US $150 in the United States and US $300 to US $350 in European Union countries in 2000. In contrast, China levied US $ 100 to US $ 150 in taxes and fees on a hectare of farmland (China Daily, 05-28-02). This policy makes farmland become a burden for farmers. It is worthwhile to question the extent to which the additional burden of agricultural taxes and fees may have been relevant determinants of farming efficiency and farmers' labor supply choice. It has a negative sign on farming efficiency, but is neither statistically nor economically significant; and it has a marginally significant positive effect on off-farm labor supply. Its positive effect on off-farm labor supply may suggest a higher degree of financial pressure as a reason for more off-farm work.

I considered the total population in the village, assuming that a larger population is companied by a more active labor market. The size of the village shows no significant effect on off-farm labor supply. A dummy variable is considered to tell the difference of the two provinces and shows insignificance. It suggests that our variables regarding local policy, land quantity and quality have very well captured the location differences. I also used a dummy variable indicating if farmers borrow to finance farming (for example, to buy chemical fertilizer and draft animals), which is not significant. It is consistent with the insignificant effect of the debt-asset ratio on off-farm labor supply that the rural credit market is not a great help for Chinese farmers.

4.6 Conclusions

This chapter explored the determinants of Chinese farmers' off-farm labor supply and investigated the relationship of the household's farming efficiency and the operator's off-farm labor supply. The findings in this chapter convey some important messages for policies.

First of all, human capital variables exhibit prominent positive effects on off-farm labor supply. It marks out the existence of off-farm labor market in rural China. Nearly twenty years (1978-1994) of economic reform have altered Chinese agricultural households' productive activities. Chinese farmers are having more opportunities in participating in off-farm labor market and are able to "sell" their labor in the labor market. Non-labor income has a negligible effect while net worth shows a positive effect on off-farm labor supply. It suggests that the substitution effect dominates the income effects for Chinese farmers' labor supply. It implies that poverty is still the norm in rural China, though it is changing for the better.

This study didn't find a significant inverse relationship between Chinese farmers' farming efficiency and their off-farm labor supply. This is no surprise given the situation of Chinese farmers: the existence of surplus labor supply due to enormous labor input in agriculture, restrictions on labor movement and tight capital constraints on household farm investment due to poverty. An endogeneity test of farming efficiency and off-farm labor supply is rejected.

Local institutional characteristics exhibit strong effects on both farming efficiency and off-farm labor supply. More information about land readjustment enhances farming efficiency. Fear of loss of land use rights is a deterrent to investing in land improvements.

The land allocation system results in the small sizes of the farms, which are a major constraint on raising farm labor productivity, because it precludes the realization of scale economies, particularly in land extensive industries. Technological innovations are best suited to larger scale farm operations. Farm efficiency could be promoted by expanding the scale of farm operations. Eventually a market for agricultural land, which allows consolidation of cultivated land in a smaller number of farms, would solve the structural problems of China's small-scale farms.

The permission of free land transfer greatly encourages off-farm labor supply, suggesting that labor mobility restrictions due to policy still exist. In one word, the absence of a land ownership system holds back rural development. The current land system is producing an agricultural surplus with very low farm incomes and massive underemployment. The transition from rigid central planning to a more market-based economy allows factors of production to move to more productive activities. The flow of labor force from the agriculture to the non-agriculture is unavoidable, especially in the case of the surplus rural labor force.

A free market in land would facilitate the efficient allocation of resources. Land markets could only be introduced when adequate nonagricultural job alternatives are created for farmers. More non-agricultural employment opportunities need to be created. In the case that land privatization is infeasible in the near future, it is necessary to facilitate the transfer of land use rights. More transparent and more flexible policies would greatly reduce transaction costs and enhance the efficiency of farmers' labor allocation.

Table 4-1 Off-Farm Employments by Sex

	Male	Female	Total
Off-Farm Job	486	8	494
No Off-Farm Job	231	22	253
Total	717	30	747

Table 4-2 Variable Definitions and Summary Statistics

Variable	Definition
Individual and Household Characteristics	
Off_hrs	Annual hours worked off-farm of the operator
Efficiency	The ratio of gross farm income to total variable costs
Male	Dummy variable, value one for male, zero for female
Age	Age of the operator
Aver_age	Average age of farm workers in the household
FarmerR	The ratio of farm workers to the total of household members
MalefarmerR	The ratio of male farmers to total farm workers in the household
Edu_year	Years of formal schooling of the operator
Training	Months of off-farm vocational training of the operator
Num_youngkids	Number of children under 10 years of age in the household
Nonlaborincome	Household income from non-labor resources (yuan)
Livestock_crop	The ratio of income from livestock to income from crop
Moderntool	Worth of farm tools such as tractor, pump and etc (yuan)
Networth	Household net worth in 1994 (yuan)
Debt_asset	The ratio of total debts to total assets
Farmland	Total farm land of the household (mu*)
Noncrop_area	The ratio of area for fruit, vegetable and etc.to total farm land
Crop_area	Area for crop/ total farmland
High	The ratio of high quality cultivated area to total cultivated area
Low	The ratio of low quality cultivated area to total cultivated area
Contract	Dummy variable, value one for procurement obligation contract
Village Characteristics	
Quota_pay	Dummy variable, value one if the village allows filling quota by cash
Land_transfer	Dummy variable, value one if the village permits free land transfer
Land_info	Dummy variable, value one if farmers are informed about land adjustment
Farmservice	Dummy variable, value one if the village helps with farm work
Enterprise	Dummy variable, value one for the presence of village enterprise
Buses	Number of buses passing by the village every day
Nonaglabor_total	The ratio of nonagricultural labor force to total labor force in the village

*1mu=0.16 acres=0.67 hectares

Table 4-2 (continued) Variable Definitions and Summary Statistics

Variable	N	Mean	Std. Dev.	Min	Max
Individual and Household Characteristics					
Off_hrs	747	1039.42	1131.29	0.00	6840
Efficiency	733	1.44	1.23	0.03	11.76
Male	747	0.96	0.20	0.00	1
Age	747	43.34	11.72	22	75
Aver_age	693	39.07	10.27	22	79
FarmerR	747	0.59	0.26	0.00	1
MalefarmerR	662	0.55	0.15	0.20	1
Edu_year	747	6.34	2.66	0.00	16
Training	747	1.20	5.09	0.00	48
Num_youngkids	747	0.52	0.69	0.00	3
Nonlaborincome	745	911.31	2166.64	0.00	25000
Livestock_crop	668	0.64	1.46	0.00	17.9
Moderntool	628	2580.32	3214.69	0.00	35015
Networth	743	31851.33	44714.94	-10603	786570
Debt_asset	743	0.06	0.23	0.00	4.27
Farmland	729	19.58	13.40	0.30	124
Noncrop_area	728	0.07	0.25	0.00	4.57
Crop_area	700	0.60	0.58	0.01	7.19
--high	683	0.39	0.39	0.00	1
--low	683	0.13	0.23	0.00	1
Contract	725	0.81	0.40	0.00	1
Village Characteristics					
Quota_pay	31	0.61	0.50	0.00	1
Land_transfer	31	0.71	0.46	0.00	1
Land_info	31	0.61	0.50	0.00	1
Farmservice	31	0.84	0.37	0.00	1
Enterprise	31	0.39	0.50	0.00	1
Buses	31	21.65	36.86	0.00	144
Nonaglabor_total	31	0.34	0.20	0.06	0.78

Table 4-3 Parameter Estimates of 2SLS

Variables	Estimate	Std. Err.	B/St.Er.	P-value
		Farm Efficiency		
Intercept	0.88	0.40	2.19	0.0287
Aver_age	0.0051	0.0052	0.99	0.3222
Edu_year	-0.003	0.023	-0.13	0.8980
Farmland	0.008	0.004	2.17	0.0303
FarmerR	-0.54	0.23	-2.32	0.0208
Malefarmer	-0.14	0.32	-0.45	0.6547
Moderntool	0.00002	0.00001	1.21	0.2267
High	0.098	0.13	0.77	0.4412
Low	-0.33	0.23	-1.42	0.1549
Contract	0.087	0.14	0.61	0.5426
Land_info	0.31	0.10	2.92	0.0037
Farmservice	0.32	0.12	2.60	0.0097
Quota_pay	0.099	0.11	0.92	0.3571
Off_hrs	0.000007	0.00007	0.10	0.9233
Smith-Blundell Tests of Hours			-0.23	0.8187
		Hours Worked Off-Farm		
Intercept	631.91	699.75	0.903	0.3665
Male	1262.41	439.22	2.874	0.0041
Age	-21.75	7.63	-2.852	0.0043
Training	23.15	13.25	1.747	0.0806
Edu_year	134.54	27.98	4.809	0.0000
Num_youngkids	10.71	107.94	0.099	0.9210
Nonlaborincome	-0.04	0.035	-1.142	0.2536
Farmland	-27.41	5.50	-4.983	0.0000
Crop_area	-1030.77	181.45	-5.681	0.0000
Noncrop_area	174.75	450.96	0.388	0.6984
Livestock_crop	-46.57	41.37	-1.125	0.2604
Debt_asset	229.43	402.58	0.570	0.5687
Networth	0.009	0.003	3.383	0.0007
Land_transfer	380.17	142.30	2.672	0.0075
Enterprise	53.28	149.18	0.357	0.7210
Buses	2.49	2.62	0.951	0.3417
Nonaglabor_total	-404.37	370.50	-1.091	0.2751
Efficiency	-303.91	249.31	-1.219	0.2228
Smith-Blundell Test of Efficiency			1.11	0.2925

Table 4-4 Marginal Effects for Selected Variables

(From LIMDEP 8.0)

Variables	Marginal effects
Nonlaborincome	-0.03
Farmland	-18.24
Crop_area	-685.92
Noncrop_area	116.29
Livestock_crop	-30.99
Debt_asset	152.67
Networth	0.006
Efficiency	-202.24
Num_youngkids	7.13
Edu_year	89.53
Training	15.41
Age	-14.47
Marginal Effects Scale Factor	0.67

Table 4-5. Bootstrap Parameter Estimates

Variables	Estimate	Std. Err.	B/St.Er.
Farming Efficiency			
Intercept	0.67	0.32	2.09
Aver age	-0.0003	0.005	-0.06
Edu year	0.01	0.02	0.5
Farmland	0.005	0.005	1
FarmerR	-0.53	0.25	-2.12
MalefarmerR	-0.07	0.34	-0.21
High	0.19	0.13	1.46
Low	-0.18	0.19	-0.95
Moderntool	0.00002	0.00001	2
Contract	0.28	0.14	2
Land info	0.42	0.09	4.67
Quota pay	0.12	0.08	1.5
Farmservice	0.36	0.10	3.6
Off hrs	-0.00007	0.00006	-1.17
Off-Farm Labor Supply			
Intercept	-556.72	2111.31	-0.26
Male	1806.40	2054.42	0.88
Age	-15.79	8.13	-1.94
Training	27.50	17.24	1.60
Edu year	162.02	31.14	5.20
Num youngkids	61.92	120.18	0.52
Nonlaborincome	-0.01	0.04	-0.25
Farmland	-22.33	5.99	-3.73
Crop area	-1056.68	159.59	-6.62
Noncrop area	163.69	682.46	0.24
Livestock crop	-30.41	46.68	-0.65
Debt asset	516.17	444.90	1.16
Networth	0.008	0.003	2.67
Land transfer	371.36	133.31	2.79
Enterprise	0.77	161.52	0.005
Buses	5.98	2.13	2.81
Nonaglabor total	-239.90	330.83	-0.73
Efficiency	-340.99	220.99	-1.54

Table 4-6 Parameter Estimates

Variables	Estimate	Std. Err.	B/St.Er.	P-value
Farm Efficiency				
Intercept	1.01	0.43	2.38	0.0176
Aver_age	0.007	0.005	1.31	0.1921
Edu_year	-0.008	0.02	-0.37	0.7080
Farmland	0.007	0.004	2.01	0.0445
FarmerR	-0.67	0.25	-2.74	0.0064
Malefarmer	-0.09	0.33	-0.27	0.7901
Moderntool	0.00003	0.00002	1.67	0.0953
High	0.06	0.13	0.43	0.6703
Low	-0.11	0.24	-0.46	0.6490
Contract	-0.008	0.14	-0.06	0.9540
Land_info	0.32	0.11	2.92	0.0036
Farmservice	0.35	0.13	2.66	0.0081
Quota_pay	0.03	0.11	0.31	0.7593
Off_hrs	-0.00003	0.00005	-0.55	0.5851
Hours Worked Off-Farm				
Intercept	229.52	547.24	0.42	0.6749
Male	1233.59	336.99	3.66	0.0003
Age	-23.38	6.79	-3.44	0.0006
Training	25.38	11.37	2.23	0.0256
Edu_year	110.95	25.3	4.39	0.0000
Num_youngkids	-1.6	97.55	-0.02	0.9869
Nonlaborincome	-0.04	0.03	-1.20	0.2285
Farmland	-26.10	4.63	-5.64	0.0000
Crop_area	-814.59	133.44	-6.11	0.0000
Noncrop_area	131.11	418.65	0.31	0.7541
Livestock_crop	-49.71	38.98	-1.28	0.2022
Debt_asset	-75.02	258.53	-0.29	0.7717
Networth	0.01	0.002	4.29	0.0000
Land_transfer	430.59	129.18	3.33	0.0009
Enterprise	57.53	136.30	0.42	0.6730
Buses	2.13	2.14	0.99	0.3206
Nonaglabor_total	-142.39	329.96	-0.43	0.6661
Efficiency	-32.8	54.13	-0.61	0.5445

Chapter 5

The Off-Farm Labor Supply of Married Farmers: A Switching Regression Model Approach

5.1 Introduction

The study in Chapter 4 used a one-person model to analyze off-farm labor supply of the farm operator. However a household usually has more than one person. The decision of one household member on off-farm work might have an interdependent relationship with labor decisions of other members. The one-person model does not capture the interesting aspect of the interdependence in the labor supply decisions. Some research has underlined the importance of the household as the relevant decision unit of the labor allocation. Lundberg (1988) tested a simultaneous equations model of a husband and spouse's work hours. The results suggest that the presence of young children has a fundamental effect on family labor supply interactions. Operators and wives without pre-school children act like separate individuals, whose work hours are not jointly determined. Families with young children exhibit strong interactions in work hours--the labor supply of operators and spouses are jointly determined.

Huffman and Lange (1989) examined joint wage-labor participation and work-hour decisions of a husband and spouse in farm households. They found that the off-farm labor supply equation of a married individual differs significantly depending on whether his or her spouse also works for a wage. Kimhi and Lee (1996) examined a full system of farm and off-farm labor supply equations of farm couples as a set of simultaneous equations with categorical dependent variables. Their main finding is that the changes of the husband's farm or off-farm labor supply affect the spouse's labor supply, but the changes of the spouse's farm or off-farm labor supply don't have significant impact on the husband's labor supply.

The implication for this research is that taking a farm household as a unitary decision maker, the off-farm labor-supply decisions of farm operators and spouses in households are dependent on each other. Even when policy measures or changes in the off-farm labor market situation only touch on certain groups of household members directly (for example, male farmers) in terms of anticipated wage levels, job availability, or economic value of home time, the policy changes would also affect time allocation of their spouses and consequently agricultural resource allocation in general if decisions are joint.

In reality, farm families show a wide spectrum in size and demographic structure, which might lead to differences in decision framework, which cannot be captured by simple increases in the number of variables or in the number of arguments in utility functions and restrictions. However, a nuclear family of a married couple with a small number of children is the dominating image of households in economic or social discussions. Therefore, like the previous studies mentioned above, this analysis is restricted to the husband-spouse model.

This chapter is dedicated to exploring whether the decision of the spouse's labor supply affects the male farm operator's off-farm labor supply behavior in rural China. The analysis of off-farm labor supply decisions is extended from an individual to the labor supply of farm couples. Operators with spouses who work off-farm are expected to have different labor supply functions than farmers whose spouses don't work off-farm. Section 5.2 presents the joint family utility maximization model for labor supply of a two-person agricultural household. Section 5.3 presents the econometric model. Since the labor force participation decision of the spouse is not independent of the husband's work decisions, an endogenous switching rule is specified to complete the model, taking into account non-negativity constraints on off-farm hours. Data and variables are discussed in section 5.4. Estimation results are reported in section 5.5. Section 5.6 summarizes the study.

5.2 Theoretical Model

To extend the analysis of labor supply decision from an individual to a family entails a theoretical problem: how to model the way the household members make their economic decisions? Lundberg (1988) described three principal classes of family labor supply models that are commonly used to motivate empirical studies: the "traditional family" model, the joint utility model, and the bargaining model.

The "traditional family" model, the most common empirical specification of family labor supply, treats the labor supply of married men as independent of the behavior of their wives while treats the husband's behavior as exogenous regarding to the spouse's work decision. The apparent inconsistency of the model is that husband and spouse maximize utility independently, with the spouse treating the husband's earnings as property income but not vice versa.

Bargaining models treat the allocation decisions of a married couple as a two-person cooperative game, which regards individuals but not households as the basic decision units. It has been pointed out that there is no standard way to formalize the structure of the 'game' of the intra-household resource allocation while it is well known that the structure of the game strongly affects the model's prediction. Moreover, the bargaining model approach often requires much more detailed data than are normally available for the empirical implementation.

The joint utility model assumes a utility function to be maximized by the household, which has the household members' attributes and economic behaviors as separate arguments and has the usual properties of the utility function from individual consumer theory. The popular applications of the theoretical results from the one-person utility maximization model advantages the joint utility model as the main theoretical framework for the empirical studies on off-farm labor supply in multiple-person agricultural households.

This chapter employs the joint utility model as the theoretical framework for the study of off-farm labor supply in multiple-person farm households. The joint utility model assumes that a family's allocation of time and goods can be analyzed as a single household-utility function, whose arguments are total consumption and the leisure times of each household member, which is maximized jointly by all members subject to a budget constraint in which all earnings are pooled. Assume both the operator and the spouse have opportunities to work on farm and off-farm, and they make all decisions to maximize their household's utility. The household's utility is a function of the total consumption good (q) and the leisure times of each member (l_H and l_s):

(5-1) $U=U(q, l_H, l_s, k)$,

Subject to:

(5-2) $pq+rX=w_H M_H + w_s M_s + P_f Q(X, K_{H,} K_{S,} F_{H,} F_{S,}) + A$

(5-3) $T_i = F_i + l_i + M_{i,}$ i=H, S

(5-4) $F_i \geq 0$, $l_i \geq 0$, $M_i \geq 0$, i=H, S

As defined in Chapter 4, w_i represents the off-farm wage rate (i=H (husband), S (spouse)), F_i represents farm hours supplied, p represents the price of the consumption good, P_f represents the price of farm output (Q), r is a column vector of prices of other farm inputs and X is a column vector of other input quantities, and A represents nonlabor income. The utility function varies according to exogenous household characteristics, which are represented by k. Farm output is produced according to the production function Q(.) using farm labor (F_H, F_s), human capital of the operator and spouse ($K_{H,}$ K_s), and other farm inputs X. The household budget constraint (5-2) depends on the off-farm income each member can receive in the labor market, the value of their time on farm activities as determined by the farm production function Q, and the level of non-labor income received by the household. Equation (5-3) represents two separate time restrictions for husband's time and for spouse's time because husband's and spouse's time are heterogeneous. The husband and spouse each exhaust their time between on-farm work, off-farm work and leisure activities.

Following the common assumption in analyses of labor allocation, we assume that the marginal utility of leisure and the consumption good approaches infinity as consumption falls to zero, thus ensuring that positive levels of leisure and the consumption good are always consumed. Optimal hours of off-farm work may be zero ($M \geq 0$).

The Langrangian function for maximizing the utility function subject to the income, time, and non-negativity constraints is:

$$L = U(q, l_H, l_s, k) + \gamma_H (T_H - F_H - l_H - M_H) + \gamma_s (T_s - F_s - l_s - M_s) \tag{5-5}$$
$$+ \lambda [w_H M_H + w_s M_s + P_f Q(X, K_H, K_s, F_H, F_s) + A - pq - r' X]$$

The Kuhn-Tucker conditions for optimality are obtained by setting the first derivatives to zero and by taking the non-negativity restrictions into account.

(5-6-1) $\frac{\partial L}{\partial X} = p_f Q_{Xn} - r_n = 0$, for inputs n=1 ….N

(5-6-2) $\frac{\partial L}{\partial M_H} = \lambda w_H - \gamma_H \le 0, \quad M_H (\lambda w_H - \gamma_H) = 0$

(5-6-3) $\frac{\partial L}{\partial M_s} = \lambda w_s - \gamma_s \le 0, \quad M_s (\lambda w_s - \gamma_s) = 0$

(5-6-4) $\frac{\partial L}{\partial F_H} = \lambda p_f Q_{F_H} - \gamma_H \le 0, \quad F_H (\lambda p_f Q_{F_H} - \gamma_H) = 0$

(5-6-5) $\frac{\partial L}{\partial F_s} = \lambda p_f Q_{Fs} - \gamma_s \le 0, \quad Fs(\lambda p_f Q_{F_s} - \gamma_s) = 0$

(5-6-6) $\frac{\partial L}{\partial q} = U_q - \lambda p = 0$

(5-6-7) $\frac{\partial L}{\partial l_H} = U_{l_H} - \gamma_H = 0$

(5-6-8) $\frac{\partial L}{\partial l_s} = U_{l_s} - \gamma_s = 0$

where λ and γ_i represent Lagrange multipliers for the household's income and each individual's time allocation. For an interior solution for the optimal allocation of time between leisure, on-farm work and off-farm work, the first portions of equations (5-6-2)-(5-6-5) hold as equalities and can be solved to yield the following condition:

$$(5\text{-}7)\ \frac{U_q}{U_{l_i}} = \frac{p}{w_i}$$

Equation (5-7) implies that the marginal rate of substitution between leisure and the consumption good is equal to the ratio of the consumption good price to the wage rate, and

$$(5\text{-}8)\ p_f Q_{F_i} = w_i$$

or that the marginal value product of farm labor is equal to the off-farm wage rate. If an individual works on the farm but not off the farm ($F_i > 0, M_i = 0$), a corner solution with $w_i < p_f Q_{F_i}$ is implied. In contrast, if an individual only works off the farm but not on the farm, a corner solution with $w_i > p_F Q_{F_i}$ is obtained. In this research, I only model off-farm labor supply. Corner solutions may exist for both the operator and spouse. Assuming the utility function is not additively separable in each member's leisure, marginal utilities are conditional on the leisure and consumption status of the other household member. Likewise, assuming farm labor inputs are not separable, marginal productivities of the head's on-farm labor depends on the spouse's level of on-farm work and vice versa. Therefore, it is implied that labor supply decisions of the head and the spouse are jointly determined.

5.3 Econometric Model

The model considered here is the endogenous switching regression model suggested by Maddala and Nelson (1975). The switching regressions model has a rich history in econometrics. Lee's (1978) union-nonunion-wage model defines two regimes as the union sector and the nonunion sector. The criterion function determines whether or not an individual joins the union. The two equations describe wage determination in the two sectors. Trost's (1977) housing-demand model defines two regimes as owner-occupied housing and rental housing. The two equations describe expenditures on housing services in the two sectors, and the criterion function determines whether the individual owns or rents the house. Other empirical examples include at-home and away-from-home food expenditure patterns, brand name selection and orange juice consumption and disequilibrium market model and etc. Ransom (1987) employed the switching regression model to study the labor supply of married men. The two regimes are defined as labor supply of married men with working wife and labor supply of married men with nonworking wife. His research found a difference between the labor supply behavior of men with working spouses and those with nonworking spouses in his study of the 1977 PSID (Panel Study of Income Dynamics) data of the USA.

Why am I motivated to investigate farmers' off-farm labor supply with the endogenous switching regression model? As stated earlier, it is commonly assumed that household members, especially husband and spouse, maximize the family's utility, therefore it is not hard to imagine that the farm operator's off-farm labor supply decision is interdependent with the spouse's off-farm labor supply decision. In other words, the status of the spouse's participation in the off-farm labor market may influence the operator's off-farm labor supply. Since a high fraction of female farmers do not work off-farm, the off-farm labor supply behavior of operators with spouse working off-farm is expected to be different from the operators with spouse not working off-farm.

The off-farm labor supply behavior of the male farm operators is described by two regression equations. Whether the farm operator's spouse works off-farm or not determines which of these two equations is applicable. We have the model

(5-9) Regime 1: $y_{1i} = \beta_1^{'} x_{1i} + u_{1i}$ if I_i=1;

(5-10) Regime 2: $y_{2i} = \beta_2^{'} x_{2i} + u_{2i}$ if I_i=0;

Regime 1 corresponds to the off-farm labor supply function of men whose spouses participate in off-farm labor market. Regime 2 corresponds to the off-farm labor supply function of men whose spouses are not involved with off-farm employment. Y_i denotes off-farm work hours, which is a function of characteristics of the operator and the household and other exogenous factors, using the Tobit method. x_{1i} and x_{2i} are vectors of explanatory variables. x_{1i} and x_{2i} are assumed to be indentical, so that we can define $x_i = x_{1i} = x_{2i}$. To be specific, regime 1 can be rewritten as:

(5-9') Regime 1: $y_{1i}^{*} = \beta_1^{'} x_{1i} + u_{1i}$ if I_i=1;

$y_{1i} = y_{1i}^{*}$ if $y_{1i}^{*}>0$, denotes as I_{1i}=1 when operator i works positive hours off-farm.

$y_{1i} = 0$ if $y_{1i}^{*} \leq 0$, denotes as I_{1i}=0 when operator i doesn't work off-farm.

Similarly, regime 2 can be rewritten as:

(5-10') Regime 2: $y_{2i}^{*}=\beta_2^{'}x_{2i}+u_{2i}$ if I_i=0;

$y_{2i}=y_{2i}^{*}$ if y_{2i}^{*}>0 , denotes as I_{2i}=1 when operator i works positive hours off-farm.

$y_{2i}=0$ if $y_{2i}^{*}\le 0$, denotes as I_{2i}=0 when operator i doesn't work off-farm.

I_i is an index of the work status of the spouse, defined as a linearized reduced-form probit equation that contains all the exogenous variables that determine the spouse's decision to work off farm, such as the characteristics of the spouse and the household.

(5-11) $I_i^{*}=\gamma^{'}Z_i+u_i$

I_i=0 if $I_i^{*}\le 0$;

I_i=1 if $I_i^{*}> 0$;

γ is a vector of parameters, and Z_i is a vector of observed variables. We assume that u_i is correlated with u_{1i} and u_{2i}, and that each error term is normally distributed. Because u_i is correlated with u_{1i} and u_{2i}, we call the model a "switching regression model with endogenous switching," as suggested by Maddala and Nelson (1975)[1]. Intuitively, it means that the hour supplied to off-farm employment of the operators is conditional on their spouse's status of participation in the off-farm labor market. The endogenous switching model is also called the mover stayer model. I is the indicator of whether the individual 'moves' (I=1) or 'stays' (I=0).

[1] Maddala and Nelson presented the relationship between the switching regression (SR) model and the disequilibrium market (DM) model. The SR model switching was based on exogenous variables. They modified the D method to make the sample partitioning a stochastic function of the exogenous variables. The DM model switching was based on endogenous variables.

In this case the sample separation I_i is observed, and we can use the probit ML to estimate the parameters γ. Because γ is estimable only up to a scale factor, we shall assume that Var(u_i)=1. We assume that u_{1i}, u_{2i}, and u_i have a trivariate normal distribution, with mean vector zero and covariance matrix

$$\Sigma = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{1u} \\ \sigma_{12} & \sigma_2^2 & \sigma_{2u} \\ \sigma_{1u} & \sigma_{2u} & 1 \end{bmatrix} \tag{5-12}$$

The likelihood function for this model is

(5-13)

$$L(\beta_1, \beta_{2,} \sigma_1^2, \sigma_2^2, \sigma_{1u,} \sigma_{2u})$$
$$= \prod \left[\left(\int_{-\infty}^{\gamma' Z_i} g(y_{1i} - \beta_1' x_{1i,} u_i) du_i \right)^{I_{1i}} \cdot \left(\int_{-\infty}^{\gamma' Z_i} \int_{-\infty}^{\beta_1' x_{1i,}} g(y_{1i} - \beta_1' x_{1i,} u_i) du_{1i} du_i \right)^{1-I_{1i}} \right]^{I_i} \cdot$$
$$\left[\left(\int_{\gamma' Z_i}^{\infty} f(y_{2i} - \beta_2' x_{2i,} u_i) du_i \right)^{I_{2i}} \cdot \left(\int_{\gamma' Z_i}^{\infty} \int_{-\infty}^{\beta_2' x_{2i,}} f(y_{2i} - \beta_2' x_{2i,} u_i) du_{2i} du_i \right)^{1-I_{21}} \right]^{1-I_i}$$

where g and f are, respectively, the bivariate normal density functions of (u_{1i} , u_i) and (u_{2i}, u_i). Since we do not observe the same individuals in both regimes, the covariance term σ_{12}=Cov (u_{1i}, u_{2i}) do not occur at all in the model and is not estimable. Only σ_{1u} and σ_{2u} are estimable, which capture the influence of correlated unobserved components in the switching and regime equations. If $\sigma_{1u}=\sigma_{2u}=0$, the model is called exogenous switching model. Intuitively, it means that the labor supplied to off-farm employment of the operators is unconditional on their spouse's status of participation in off-farm labor market. The switching regression models are estimated in Limdep 8.0, which presents a full information maximum likelihood estimator that jointly estimates γ, β_1, β_2, σ_1^2, σ_2^2, σ_{1u} and σ_{2u}.[2]

5.4 Data and Variables

The data for the analysis is the same data used in chapter 4, from the World Bank's 1995 North and Northeast China Living Standard Survey. It covered 787 households in 6 counties, 18 townships and 30 villages in the northern province of Hebei and the northeast province of Liaoning. The survey provides detailed information about household characteristics (e.g. demographic structure, education, housing conditions, farm size) and economic activities (e.g. farm management, own non-agricultural business, off-farm jobs, household expenditures, gifts, remittances, savings and loans). For the analysis in this chapter, I keep the households with both spouses present and both younger than 60 years old. The switching regression models are applied to a sample consisting of 684 husband-spouse households. In 198 households, the spouse works off-farm. In 164 households, the spouse works both on farm and off farm. In 486 households, the spouse doesn't work off-farm. In 186 households, both the operator and the spouse work off-farm. Table 5-1 describes the construction of the sample. Off-farm labor supply is measured by annual hours supplied to off-farm employment. The definitions of the variables used in the estimation are described in Table 5-2. Table 5-3 describes the summary statistics of the two groups respectively. The data show that compared with operators whose spouses don't work off-farm, operators with spouses working off-farm on average are younger (37.99 years vs. 42.17 years), are furnished

[2] Limdep 8.0 Econometric Modeling Guide E23-57.

with better human capital (education: 7.37 years vs.6.56 years; vocational training: 1.79 months vs.1.01 months), and supply more hours to off-farm employment (1717.63 hours vs. 923.53 hours). Households with the spouse working off-farm have higher net worth (44875.13 Yuan vs.28584.27 Yuan) and receive less non-labor income (706.80 Yuan vs. 884.82 Yuan).). Households with spouse not working off-farm operate larger farmland on average (40.21 mu vs.17.57 mu).

The empirical variables can be categorized into three groups. The first group are individual variables of the operator: age, education (formal schooling years) and months of vocational off-farm training; and individual variables of the spouse: age, education (formal schooling years) and months of vocational off-farm training. The range of opportunities facing an individual farmer is likely to be determined by their stock of talents and expertise. Generally, an individual's stock of human capital and thus their non-farm marginal wage may be reflected in their formal education, age and experiences working in non-farm activities. Age is an important demographic indicator of the preferences of individuals, such that the older individual may have different views and attitudes about employment. Years of formal schooling and months of non-farm vocational training are used as indicators of an individual's stock of human capital. The effect of formal education on the off-farm labor supply includes both direct and indirect effects. If formal education enhances an individual's performance in farming activities, it increases the shadow value of labor. A better-educated person has better opportunities in the off-farm labor market and higher wages are paid to more educated workers. Non-farm vocational training is expected to increase his off-farm labor supply. I am also interested in testing the cross effects of the operator's human capital on the spouse's participation decision.

The second group contains household relevant variables: the total farmland owned by the family (FARMLAND) is used commonly to measure the scale of farm work. Crop cultivation has been the major farm activity for Chinese farmers. The more the farmers concentrate on crop cultivation, the less time they have for other activities. The ratio of area for crop cultivation to the total farmland (CROP_AREA) is expected to be negatively related to off-farm labor supply. The ratio of area for vegetables and fruits to crop cultivation area (VEG_CROP) and the ratio of income from livestock operation to the income from crop cultivation (LIVESTOCK_CROP) affect off-farm labor supply through both time constraints and budget constraints because labor demand and income of production of vegetables and fruits and livestock operation are different. The ratios of high (low) quality crop area of total cultivated area (HIGH and LOW) are included to account for land quality. The expected effect is uncertain. HIGH may decrease on-farm labor requirements and therefore increase off-farm labor supply or its relatively high productivity may encourage farmers to spend more time on farm. LOW may increase on-farm labor requirements and hence decrease off-farm labor supply or its relatively low productivity may discourage farm effort. Non-labor income and net worth are included to capture the effect of exogenous non-wage income on the consumption of leisure. If leisure is a normal good, higher levels of income from non-labor sources would result in fewer hours of off-farm employment. The effect of NUM_YOUNGKIDS (number of children under 10 years old) is uncertain, depending if the cost of young children in terms of home time is dominant over their money cost. As dependents, young children increase the household's subsistence level of both consumption goods and childcare time. The dummy variable OFF_CH has a value of one if the household has adult children working off-farm. The effect of OFF_CH on off-farm labor supply is ambiguous. An adult child working off-farm may reduce the subsistence level by supplying off-farm income and hence decreasing the parents' off-farm labor supply. At the same time, an adult child working off-farm implies better social network in the off-farm labor market, which improves the parents' opportunities in off-farm labor market.

The third group contains regional relevant variables: the dummy variable LAND_TRANSFER has a value of one if the village authority permits free land transfer. It is expected to have positive effects on off-farm labor supply since free land transfer decreases farmers' opportunity cost of participating in off-farm labor market. The dummy variable ENTERPRISE has a value of one if the village has at least one rural enterprise, which is supposed to grant more off-farm employment opportunities to local farmers. The number of buses passing by the village daily (BUSES) is used to catch the effect of transportation. Better transportation is anticipated to positively affect off-farm employment.

5.5 Estimation Results and Discussions

Two versions of the model are estimated using the maximum likelihood method in Limdep 8.0. The first version assumes an "exogenous switch," which means that the error term in the spouse's participation equation is not correlated with the error term in either operator's off-farm labor supply equation. The implication is that the operator's off-farm labor supply decision is independent from the spouse's participation status in the off-farm labor market. The second version is the general endogenous switching regression model discussed above, which implies that the operator's off-farm labor supply decision is conditional on the spouse's participation status in the off-farm labor market.

First, we consider the estimation results of the probit equation. Then we discuss the estimates of the operator's labor supply functions. The estimated values of the parameters are reported in Table 5-4.

The probit equation helps us to determine to what extent the different factors influence a spouse's decision to participate in the off-farm labor market. In the exogenous switching model, the estimation of the labor force participation equation is a simple probit. Comparing probit estimates with the corresponding values of the endogenous switching model will give an idea of the importance of the simultaneity of the operator's work decision and the participation decisions of the spouse. The parameter estimates of the probit function are qualitatively similar in the two specifications but exhibit some differences in magnitude. In the endogenous switching model, the spouse's vocational training (F_TRAINING) and formal education years (F_EDU) highly increase their probability of participation in off-farm labor market. The strong positive effects of human capital prove the existence of off-farm labor markets in the rural area.

The spouse's age (F_AGE) has a significant negative effect. A younger woman is more willing to work off-farm and is more employable in the off-farm labor market. Contrary to the stylized fact in many countries that the incidence of young children negatively influences women's labor supply decision, NUM_YOUNGKIDS came out to be insignificant. The results show that for Chinese married female farmers, having young children does not have a major impact on the decision to work off-farm. The tradition in

China is that grandparents help with child rearing, which may offset the negative effects of young children on a mother's labor supply by lowering the costs of child rearing. Adult children working off-farm (OFF_CH) don't have much effect on the spouse's off-farm labor decision. CROP_AREA shows a strong negative effect. Larger area crop cultivation demands more farming labor supply, thus reduce the spouse's probability of participating in the off-farm labor market. LOW has a strong negative effect and HIGH doesn't show a significant effect. One may argue that low land qualities tend to discourage farmers to work on farm and consequently through time constraint encourages farmers to participate in the off-farm market. However, under the land allocation system and the grain quota system, Chinese farmers are obligated to crop cultivation. Therefore it is not surprising that low land quality decreases the spouse's probability of participation in off-farm labor market since it demands more farm labor supply. Neither VEG_CROP nor LIVESTOCK_CROP has significant effect on the spouse's off-farm employment status. One possible explanation is that the scales of livestock operation and vegetable-fruits production are not large enough to make a difference. As expected, NONLABORINCOME has a significant negative impact. Women from families having higher non-labor income are less likely to participate in the off-farm labor market, showing that leisure is a normal good for the female farmers. NETWORTH has significant positive effects on the spouse's participation decision.

BUSES are positively related to spouse's participation in off-farm labor markets. Better transportation increases the spouse's probability of participation in the off-farm labor market. The village policy of whether land is freely transferable (LAND_TRANSFER) has positive but insignificant effect on the spouse's probability of participation in the off-farm labor market. Unexpectedly, ENTERPRISES shows no significant effect and it has a negative sign. The negative sign may suggest that rural enterprises are not a good source of off-farm employments for female farmers. The results from the probit equation show that human capital variables of the spouse (F_AGE, F_TRAINING and F_EDU), financial characteristics of the family (NONLABORINCOME, NETWORTH), family crop cultivation (CROP_AREA, LOW) and transportation (BUSES) are the main factors determining the spouse' s work status in the off-farm labor market. I also included the human capital variables of the operator (M_AGE, M_TRAINING and M_EDU) in the probit estimation. The results show that neither the human capital variables of the operator nor the human capital variables of the spouse have significant effects, which suggests that collinearity exists between the two groups of variables. A likely explanation is that people with richer human capital tend to have spouses with matching characteristics.

The exogenous switching model implies that the spouse's off-farm work status is not endogenous to the operator's off-farm labor supply. F_AGE has a more significant negative effect than in the endogenous version. Likewise, both F_TRAINING and F_EDU increase the spouse's probability of participating in the off-farm labor market. The effect of F_EDU is less significant. NONLABORINCOME has a similar significant negative effect and NETWORTH has a similar positive effect. CROP_AREA has a similar negative impact. BUSES have a similar positive effect. ENTERPRISES also have no significant effect. The exogenous switching model showed some significant differences. LOW has a positive important effect, the opposite of the endogenous version. LIVESTOCK_CROP showed no significant effect in the endogenous model but has a significant negative effect in the exogenous model. LAND_TRANSFER has a significant positive effect in the exogenous model but no significant effect in the endogenous model. In another word, if the simultaneity between the spouse's off-farm labor market participation decision and the operator's off-farm labor supply decision is not taken into account, low quality land encourages the spouse to participate in the off-farm labor market; the spouse supply more labor to livestock operation and are less likely to be involved with off-farm employment; permission of free land transfer highly increases the spouse's probability of working off-farm.

As for the operator's off-farm labor supply function, once again the parameter estimates exhibit some differences. A likelihood ratio test rejects the exogenous switching model in favor of the endogenous switching model. Consider the parameter estimates of the operators' off-farm labor supply function in the endogenous switching model. Age of the operator (M_AGE) has a negative sign in both groups but not significant. Age has no pronounced effect on operators' off-farm labor supply. Formal schooling years (M_EDU) has strong positive effects on all operators' off-farm labor supply, but is more significant for the group with a spouse not working off farm. Vocational training (M_TRAINING) has no significant effect on the group with a spouse working off-farm and has a marginal significant positive effect on the group.

NONLABORINCOME shows no significant impact on off-farm labor supply of both groups. It may suggest that leisure is not a normal good for male farmers whether or not the spouse works off-farm. NETWORTH has positive effects on the off-farm labor supply of operators in both groups but with more pronounced effects on the group with spouse working off-farm. The positive effect of net worth and the negligible effect of non-labor income suggest that the substitution effect dominates the income effect for the labor supply of Chinese male farmers; and leisure may not be a normal good for them due to poverty. The more pronounced effect of net worth on the group with spouse working off-farm suggests that the households in a better economic situation are more likely to have both husband and spouse working off-farm. FARMLAND and CROP_AREA greatly decrease the off-farm work hours of the operators whose spouses don't work off-farm. For the group with spouse working off-farm, FARMLAND shows a marginal significant negative effect and CROP_AREA shows no significant effect. The data show that the average area of farmland of the households whose spouses don't work off-farm is 40.21 mu, much larger than the average area of the other group which is 17.57 mu. The ratio of vegetable and fruits area to crop area (VEG_CROP) and the ratio of livestock income to crop income (LIVESTOCK_CROP) decrease off-farm work hours of the group with spouse working off-farm but don't have much effect on the other group. It seems that the operator supplies more labor for the farm operation when the spouse works off-farm. The ratio of low quality cultivated land (LOW) has no significant effect on both groups. The ratio of high quality cultivated land (HIGH) significantly decreases the off-farm work hours of the operators whose spouses work off-farm but doesn't have much effect on the other group. Combined with the probit results, it seems that female farmers tend to work on low quality land while the male farmers tend to work on high quality land.

NUM_YOUNGKIDS shows significance in neither group, which is not surprising since young children don't even have much effect on the mother's labor supply decision. OFF_CH shows strong positive effect for the group with spouse working off farm but no significant effect for the other group. BUSES substantially increases off-farm work hours of the operators whose spouse works off-farm, but doesn't have much effect on the group whose spouse don't work off-farm. Combined with the results from the probit equation that

BUSES increase a spouse's probability of participating in the off-farm labor market, we can conclude that in areas with better transportation, it is more likely for both the operator and the spouse to work off-farm.

ENTERPRISES increases the off-farm work hours of the operators with spouses not working off-farm but have no significant effect on the operators with spouses working off-farm. The results of the probit equation showed negative effects of ENTERPRISES on the spouse's participation in the off-farm labor market. All these results may indicate that the spouses of the operators working in rural enterprises are less likely to participate in off-farm labor markets. LAND_TANSFER significantly increases the off-farm work hours of the operators with spouses not working off-farm but doesn't have much effect on the operators with spouse working off-farm. One possible explanation for the different effects is that the households with both the operator and the spouse working off-farm are in a better economic situation and they on average operate a smaller farm; whether their land is transferable or not, the opportunity costs for off-farm employment are more bearable for them.

The correlation coefficients are both significantly different from zero. The correlation between errors in the spouse's participation equation and the off-farm labor supply function of operators with spouses working off-farm is positive. The correlation between errors in the spouse's participation equation and the off-farm labor supply function of operators whose spouses don't work off-farm is negative. The results may suggest that operators with spouses working off-farm are likely to supply more labor to off-farm employment while the operators with spouses not working off-farm are likely to supply less labor to off-farm employment.

The exogenous switching model doesn't take into account the simultaneity between the spouse's work status in the off-farm labor market and the off-farm labor supply of the operator. Some family characteristics that are significant in the endogenous model become insignificant in the exogenous model. For example, HIGH and VEG_CROP become insignificant for operators whose spouses work off-farm; FARMLAND and CROP_AREA become insignificant for operators whose spouses don't work off-farm.

Using the estimated parameters, we can evaluate the labor supply elasticity for each individual in the sample conditional on the regime status of the family. The labor supply elasticity with regard to net worth at the mean is presented in Table 5-5. The elasticity is biased downward for operators in both regimes when simultaneity is ignored.

5.6 Conclusions

A switching regressions model of the off-farm labor supply of male operators is presented in the paper, which accounts for "spillovers" that result when the spouse is constrained by the non-negativity of off-farm work hours. An endogenous switching model assumes that the work status of the spouse in the off-farm labor market is endogenous to the off-farm labor supply of the operators. The correlation coefficients are significantly different from zero, suggesting that the off-farm labor supply decisions of the operator and the spouse are jointly made. An exogenous switching model ignores the simultaneity of the participation decisions of the spouse and the off-farm labor supply decisions of the operator. A likelihood ratio test rejects the exogenous switching model in favor of the endogenous switching model.

Taking into account the simultaneity of the participation decision of the spouse and labor supply decision of the operator, the research finds a difference between the off-farm labor supply behavior of farmers with spouses working off-farm and those with spouses not working off-farm. The magnitudes of the different intrahousehold effects depend on the working status of adult children (OFF_CH), household agricultural production characteristics --FARMLAND, CROP_AREA, quality of cultivated land (HIGH), the ratio of vegetable and fruit area to crop area (VEG_CROP) and regional conditions such as local transportation (BUSES) and village policy whether or not land is freely transferable. Operators with spouse not working off-farm on average cultivate a larger area of farmland and crop area, which significantly reduces their off-farm labor supply; consequently they are likely to offer more off-farm labor if their farmland is freely transferable; and the presence of the village's rural enterprise significantly increases their off-farm labor supply. Operators with spouses working off-farm tend to increase their off-farm labor supply when they have adult children working off-farm (OFF_CH) and have better transportation availability (BUSES); and they tend to reduce their off-farm labor supply if they have a larger ratio of high quality cultivated area (HIGH) and a larger ratio of vegetable and fruit area to crop area (VEG_CROP).

Formal education substantially increases all operators' off-farm labor supply. The labor supply elasticity to net worth is positive for operators in both regimes, and it has a larger value for the operators with spouse working off-farm. Households with both the operator and the spouse working off-farm are in a better economic situation. Income from non-labor sources exhibit no significant effect on all operators' off-farm labor supply. The results suggest that the substitution effect dominates the income effect for the operators' labor supply.

The findings in this chapter support that the agricultural household is a more relevant decision unit for resource allocation than is its individual members. The policy implications are that even when changes of relevant policies and changes in the off-farm labor market only touch on certain groups of household members directly (for example, male farmers) in terms of anticipated wage levels, job availability, or economic value of home time, the policy changes would also affect time allocation of their spouses and consequently agricultural resource allocation in general. The information is important for making rural economic development policies by help conforming between different political objectives and various measures. Future work can be extended to the switching nature of the spouse's off-farm labor supply depending on the operator's work status in the off-farm labor market.

Table 5-1 Table of M_off by F_off

M_off \ F_off	0	1	Total
0	172	12	184
1	314	186	500
Total	486	198	684

M_off=1 The operator works off-farm
F_off=1 The spouse works off-farm

Table 5-2. Definition of Variables

Variable	Definition
F_off	Dummy variable having value one if the spouse works off-farm
Moff_hrs	Annual hours supplied to off-farm employment by the operator
F_age	Years of age of the spouse
M_age	Years of age of the operator
F_edu	Years of formal schooling of the spouse
M_edu	Years of formal schooling of the operator
F_training	Months of off-farm vocational training of the spouse
M_training	Months of off-farm vocational training of the operator
Num_youngkids	Number of children under 10 years of age in the household
Nonlaborincome	Household income from non-labor resources (Yuan)
Networth	Household net worth in 1994 (Yuan)
Farmland	Total area of the farm land of the household (Mu[*])
Crop_area	The ratio of area for crop cultivation to the total area of farm land, 1994
High	The ratio of high quality crop cultivation area to the total crop cultivation area
Low	The ratio of low quality crop cultivation area to the total crop cultivation area
Livestock_crop	The ratio of income from livestock operation to the income from crop cultivation, 1994
Veg_crop	The ratio of area for vegetable and fruit production to the area for crop cultivation, 1994
Off_Ch	Dummy variable having value one if the family has adult children working off-farm
Land_transfer	Dummy variable having value one if the village authority permits free land transfer
Enterprise	Dummy variable having value one if the village has at least one rural enterprise
Buses	Number of buses passing by the village everyday

[*] 1Mu=0.16 Acres=0.67 Hectares

Table 5-3. Summary Statistics of Variables

Variable	Households that spouse works off-farm (F_off=1)					Households that spouse doesn't work off-farm (F_off=0)				
	N	Mean	Std. Dev	Min	Max	N	Mean	Std. Dev	Min	Max
Moff hrs	198	1717.63	1161.87	0.00	6840	486	923.53	1031.47	0.00	4320
F_age	198	36.70	7.56	22	57	486	40.41	9.31	22	60
M_age	198	37.99	8.14	22	59	486	42.17	9.67	23	60
F_edu	198	6.11	2.91	0.00	13	485	5.05	2.95	0.00	16
M_edu	198	7.37	2.18	0.00	13	486	6.56	2.37	0.00	16
F_training	198	1.15	5.79	0.00	48	485	0.15	1.99	0.00	36
M_training	198	1.79	6.27	0.00	48	486	1.01	4.30	0.00	48
Num_youngkids	198	0.72	0.72	0.00	3	486	0.53	0.69	0.00	3
Nonlaborincome	198	706.80	2223.78	0.00	25000	485	884.82	1878.29	0.00	13400
Networth	197	44875.12	73532.14	-80	786570	483	28584.27	26410.28	-10603	194300
Farmland	189	17.57	12.17	1.80	73	479	40.21	432.05	0.30	9471.01
Crop_area	176	0.49	0.30	0.07	2.54	468	0.67	0.67	0.002	7.19
High	176	0.40	0.42	0.00	1.00	454	0.39	0.38	0.00	1.00
Low	176	0.11	0.23	0.00	1.00	454	0.15	0.24	0.00	1.00
Livestock_crop	157	0.66	1.68	0.00	15.81	454	0.64	1.45	0.00	17.90
Veg_crop	185	0.10	0.26	0.00	2.63	473	0.17	1.11	0.00	21.50
Off_Ch	198	0.09	0.29	0.00	1.00	486	0.16	0.37	0.00	1.00
Land_transfer	198	0.77	0.42	0.00	1.00	486	0.71	0.45	0.00	1.00
Enterprise	198	0.38	0.49	0.00	1.00	486	0.34	0.48	0.00	1.00
Buses	198	28.12	43.46	0.00	144	486	14.49	27.37	0.00	144

Table 5-4. Parameter Estimates of the Switching Model

Variable	Endogenous Switching Model				Exogenous Switching Model			
	Estimate	Std.Er.	B/Std.Er	P-value	Estimate	Std.Er.	B/Std.Er	P-value
Elements of probit								
Constant	0.74	0.56	1.33	0.1833	0.24	0.41	0.57	0.5706
F_age	-0.03	0.01	-2.53	0.0114	-0.03	0.01	-3.48	0.0005
F_edu	0.04	0.02	1.72	0.0855	0.03	0.02	1.62	0.1043
F_training	0.03	0.01	2.21	0.0270	0.04	0.02	2.52	0.0117
Off_ch	0.04	0.22	0.18	0.8559	-0.07	0.18	-0.38	0.7041
Num_youngkids	-0.08	0.12	-0.67	0.5063	-0.07	0.1	-0.67	0.5022
Farmland	-0.008	0.005	-1.51	0.1300	-0.0003	0.0005	-0.66	0.5100
Crop_area	-0.67	0.20	-3.41	0.0007	-0.48	0.14	-3.51	0.0004
High	-0.11	0.18	-0.61	0.5429	0.17	0.12	1.38	0.1686
Low	-0.81	0.34	-2.37	0.0180	0.32	0.15	2.08	0.0379
Nonlaborincome	-0.0001	0.52D-04	-2.53	0.0113	-0.0001	0.38D-04	-2.76	0.0058
Veg_crop	-0.08	0.25	-0.32	0.7475	0.0001	0.0003	0.37	0.7102
Livestock_crop	0.04	0.04	0.99	0.3201	-0.0007	0.0003	-2.75	0.0060
Networth	0.56D-05	0.29D-05	1.93	0.0535	0.72D-05	0.21D-05	3.44	0.0006
Land_transfer	0.20	0.16	1.25	0.2111	0.23	0.13	1.82	0.0694
Enterprise	-0.21	0.18	-1.18	0.2380	-0.21	0.14	-1.57	0.1157
Buses	0.006	0.002	2.19	0.0287	0.006	0.002	3.08	0.0021
Elements of β_1								
Constant	371.32	837.25	0.44	0.6574	526.68	662.57	0.8	0.4267
M_age	-4.88	17.21	-0.28	0.7767	-0.52	12.83	-0.04	0.9677
M_edu	95.02	48.75	1.95	0.0513	87.93	40.08	2.19	0.0283

M_training	-12.88	20.99	-0.61	0.5393	17.64	13.61	1.3	0.1949
Off_ch	1053.34	414.71	2.54	0.0111	1014.60	299.18	3.39	0.0007
Num_youngkids	-51.10	168.45	-0.3	0.7616	-15.33	139.72	-0.11	0.9126
Farmland	-15.07	9.98	-1.51	0.1309	0.63	0.50	1.26	0.2081
Crop_area	-219.27	410.65	-0.53	0.5934	78.15	227.10	0.34	0.7307
High	-407.58	242.26	-1.68	0.0925	-236.69	170.39	-1.39	0.1648
Low	94.34	856.86	0.11	0.9123	157.89	243.96	0.65	0.5175
Nonlaborincome	-0.058	0.17	-0.33	0.7388	-0.07	0.05	-1.42	0.1550
Veg_crop	-991.41	590.78	-1.68	0.0933	-0.22	0.43	-0.52	0.6036
Livestock_crop	-100.84	63.51	-1.59	0.1123	0.20	0.28	0.73	0.4669
Networth	0.016	0.004	3.99	0.0001	0.004	0.002	2.47	0.0134
Land_transfer	150.95	270.69	0.56	0.5771	172.10	197.66	0.87	0.3839
Enterprise	-301.21	311.42	-0.97	0.3335	9.96	210.90	0.05	0.9623
Buses	6.96	4.12	1.69	0.0912	5.36	2.47	2.17	0.0302
Elements of β_2								
Constant	75.29	611.61	0.12	0.9020	-794.36	518.37	-1.53	.1254
M_age	-2.86	10.95	-0.26	0.7937	-8.44	9.44	-0.89	.3717
M_edu	92.87	34.24	2.71	0.0067	136.25	30.68	4.44	.0000
M_training	28.62	18.41	1.56	0.1199	21.52	15.23	1.41	.1578
Off_ch	122.46	206.08	0.59	0.5523	198.75	194.10	1.02	.3058
Num_youngkids	122.26	149.84	0.82	0.4145	176.52	125.67	1.41	.1601
Farmland	-31.63	6.45	-4.91	0.0000	-0.19	0.27	-0.71	.4772
Crop_area	-713.27	155.32	-4.59	0.0000	-0.23	0.71	-0.32	.7495
High	291.15	214.19	1.36	0.1741	145.40	140.72	1.03	.3015
Low	137.85	345.26	0.40	0.6897	-145.42	140.75	-1.03	.3015
Nonlaborincome	0.038	0.052	0.73	0.4632	0.04	0.04	1.18	.2386
Veg_crop	12.41	201.23	0.06	0.9508	-0.02	0.32	-0.07	.9411
Livestock_crop	-14.77	45.04	-0.33	0.7429	0.28	0.41	0.69	.4915
Networth	0.004	0.004	1.12	0.2638	0.003	0.003	1.12	.2645

Land transfer	466.74	179.77	2.6	0.0094	659.54	150.14	4.39	.0000
Enterprise	311.57	179.20	1.73	0.0821	213.40	153.84	1.39	.1654
Buses	-4.17	4.21	-0.99	0.3222	-0.72	2.72	-0.27	.7912
Variance/covariance								
σ_1^2	1393.44	102.68	13.57	0.0000	1069.17	56.28	19.00	.0000
σ_2^2	1080.96	202.07	5.35	0.0000	1359.14	58.62	23.19	.0000
σ_{1u}	0.579	0.346	1.67	0.0948	*****	*****	*****	*****
σ_{2u}	-0.692	0.179	-3.86	0.0001	*****	*****	*****	*****
Log Likelihood		-3856.354				-4414.134		

Table 5-5 Conditional Labor Supply Elasticity

(Calculated at the Mean)

Group	Endogenous Switch Model	Exogenous Switch Model
F_off=1 *(N=198)*		
Elasticity (net worth)	0.42	0.10
F_off=0 *(N=486)*		
Elasticity (net worth)	0.12	0.09

Chapter 6

Farm Household Technical Efficiency and Off-Farm Labor Supply: A Stochastic Frontier Approach

6.1 Introduction

Efficiency measurement has been the concern of a goal to investigate the efficiency levels of farmers engaged in agricultural activities. The first motivation of this chapter is to provide an alternative estimation approach to consider household farming efficiency. Stochastic production frontier models are employed to measure farm household-specific technical efficiency. The second goal is to assess the relationship between farm household technical efficiency and the operator's off-farm labor supply. Section 6.2 introduces the theoretical framework of stochastic production function models. Section 6.3 presents an empirical procedure and discusses the data. I will develop two measures of technical efficiency: crop production technical efficiency and agricultural production technical efficiency that includes production activities of all crops, livestock, vegetables and fruits. The reason for separate analysis of crop production technical efficiency is that crop production has been the most important agricultural activity for the majority of Chinese farmers since aggregate grain output has always been the main concern of the government. Moreover, it is obvious that the production processes for crop cultivation and other activities such as animal husbandry are not the same, the separate measure of crop production technical efficiency may have fewer measurement errors. Crop production technical efficiency is discussed in section 6.3.1 and agricultural production technical efficiency is discussed in section 6.3.2. Section 6.3.3 examines the relationship of the operator's off-farm labor supply to the two versions of technical efficiency. Section 6.4.1 provides empirical results of crop production technical efficiency and off-farm labor supply and section 6.4.2 provides empirical results of an analysis of agricultural production technical efficiency and off-farm labor supply. Section 6.5 draws some concluding remarks.

6.2 Theoretical Model[1]

Generally speaking, efficiency can be considered in terms of the optimal combination of inputs needed to achieve a given level of output (an input-orientation), or the optimal output that could be produced given a set of inputs (an output-orientation). Technical efficiency is just one component of overall economic efficiency. In order to be economically efficient, a producer must first be technically efficient. Profit maximization requires a producer to produce the maximum output given the level of inputs employed (i.e. be technically efficient), to use the right mix of inputs in light of the relative price of each input (i.e. be input allocative efficient) and to produce the right mix of outputs given the set of prices (i.e. be output allocative efficient) (Kumbhaker and Lovell 2000). Our initial task is to introduce methodological matters considered in estimating technical efficiency.

Production Possibility Sets and Production Frontiers

1 Discussion in this section draws from Kumbharkar C. Subal and Lovell C.A. Knox "Stochastic Frontier Analysis" 2000 Cambridge University Press and Herrero Inés and Pascoe "Estimation of Technical Efficiency: A Review of Some of the Stochastic Frontier and DEA Software Computers in Higher Education" Economics Review 2002 Vol.15 Issue1.

Assume that producers use a nonnegative vector of inputs, denoted $x = (x_1,..., x_N) \in R_+^N$, to produce a nonnegative vector of outputs, denoted $y = (y_1,..., y_N) \in R_+^M$. The production possibility set of a producer is a subset T of the space R_+^{M+N}, which is the collection of all feasible input and output vectors of the producer. A producer may choose an input-output configuration $(x, y) \in T$ as its production plan. The formal definition is given as

$$T = \{(y, x): \text{x can produce y}\} \subset R_+^{M+N}$$

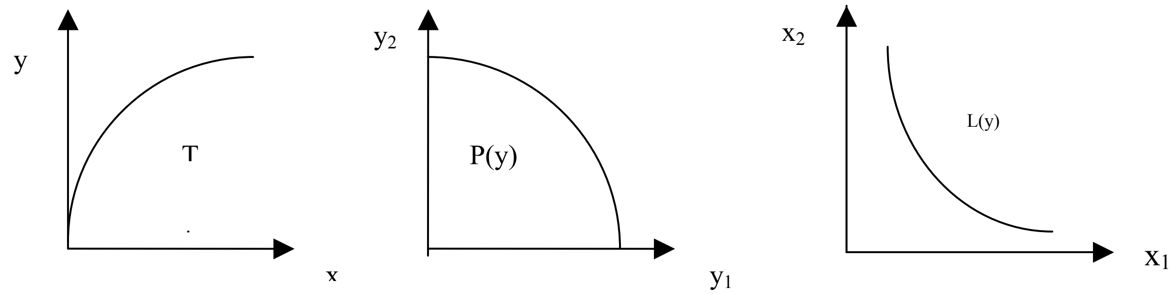
A production possibility set can also be represented by an input requirement set L(y) or output producible set P(x) (Färe, Grosskopf and Lovell, 1994). The input requirement set is the collection of all input vectors $x = (x_1,..., x_N) \in R_+^N$ that yield at least output vector $y = (y_1,..., y_M) \in R_+^M$. It can be denoted as

$$L(y) = \{x: (x, y) \text{ is feasible}\}$$

The output producible set is the collection of all output vectors $y = (y_1,..., y_M) \in R_+^M$ that could be produced from the given input vector $x = (x_1,..., x_N) \in R_+^N$. It can be denoted as

$$P(x) = \{y: (x, y) \text{ is feasible}\}$$

Figure 1 below illustrates these production possibility sets.



(a) Input-Output Sets (M=1, N=1) (b) Output Producible Set (M=2, N=1) (c) Input Requirement Set (M=1, N=2)

Figure 1 Production Possibility Sets

Given a boundary of production technologies, an n-dimensional vector of input x produces a single output y. Suppose the production possibility set satisfies $T(x, y) \geq 0$. A general production frontier can be represented as $y = f(x)$. $y = f(x)$ gives the upper boundary of T. Given input x, the maximum producible output that can be achieved is given by $y = f(x)$. A formal definition of the production frontier is given as:

$$f(x) = \max\{y : y \in P(x)\} = \max\{y : x \in L(y)\} = \max\{y : T(x, y) \geq 0\}$$

The production frontier only contains the efficient observations of a producer, and thus serves as a standard against which to measure the technical efficiency of production.

Distance Functions

The central problem in the measurement of technical efficiency is to measure the distance from each producer's input-output combination to the efficient production frontier. Shepherd's (1953, 1970) distance functions provide a functional characterization of the structure of production technology, when multiple inputs are used to produce multiple outputs. Input distance functions characterize input sets; output distance functions characterize output sets. The main role played by distance functions is in duality theory. Under certain conditions, a single-output production frontier is dual to a single-output cost frontier and an input distance function is dual to a cost frontier. Likewise, an output distance function is dual to a revenue frontier under certain conditions. Distance functions can be estimated econometrically to measure technical efficiency.

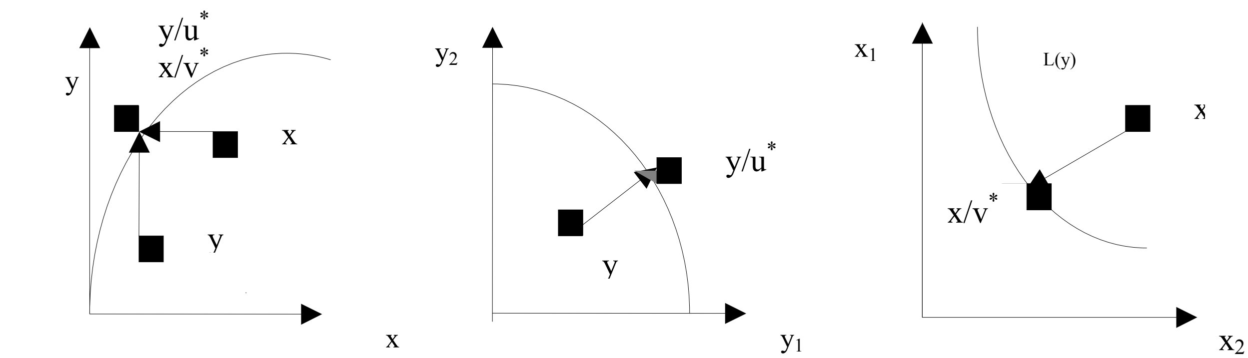
An input distance function adopts an input-conserving approach to measure the distance from a producer's input vector to the boundary of production possibilities. It can be represented as:

$$D_1(y,x) = \max\{v : x/v \in L(y)\}.$$

An input distance function gives the maximum amount by which a producer's input vector can be shrunk and still be feasible for the output vector it produces. An input distance function is illustrated in Figure 2 (a) and (c). Input vector x is feasible for output y, but y can be produced with a contracted input vector (x/v^*), so $D_1(y, x) = v^* > 1$.

An output distance function takes an output-expanding approach to measure the distance from a producer's output vector to the boundary of production possibilities. It can be represented as:

$$D_0(y,x) = \min\{u : y/u \in P(x)\}$$



(a) An Input and Output Distance Function (M=1, N=1)

(b) An Output Distance Function (M=2)

(c) Input Requirement Set (N=2)

Figure 2 Distance Functions

An output distance function gives the minimum amount by which an output vector can be reduced and stay producible with a given input vector. An output distance function is illustrated in Figure 2 (a) and (b). Output y is producible with input vector x, but so is a larger output (y/u^*), so $D_0(y, x) = u^* < 1$.

Technical efficiency

In general, technical efficiency refers to the ability of a producer to minimize input use in the production of a given output vector, or the ability to obtain maximum output from a given input vector. The analysis of technical efficiency could be output augmenting oriented or input conserving oriented. Koopmans (1951, p.60) provided a formal definition of technical efficiency: a production unit is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output. A technically inefficient producer produces the same outputs with more of at least one input, or uses the same inputs for less of at least one output.

The formal definition of technical efficiency is given as: a producer unit with input-output configuration $(x, y) \in T$ is technically efficient if there is no $(x', y') \in T$ for $(x', y') \neq (x, y)$ with $x' \leq x$ and $y' \geq y$.

Debreu (1951) and Farrell (1957) proposed a measure of technical efficiency, which is defined as one minus the maximum equally proportionate reduction of all inputs that still permits continued production of given outputs. A unity score represents technical efficiency because no equally proportionate input reduction is allowed, and a less than unity score represents technical inefficiency. Farrell's measure allows assessment of technical efficiency by using input and output quantity when prices of inputs and outputs are unavailable.

Figure 3 graphically illustrates the concepts of an input-oriented efficiency and an output-oriented efficiency by using a simple example of a two-input (x_1, x_2), two-output (y_1, y_2) production process. In Figure 3(a), the producer is producing a given level of output (y_1^*, y_2^*) using an input combination defined by point A. The same level of output could have been produced by reducing the use of both inputs back to point B, which lies on the isoquant associated with the minimum level of inputs required to produce (y_1^*, y_2^*) (i.e. Iso(y_1^*, y_2^*)). The input-oriented level of technical efficiency ($TE_I(y, x)$) is defined by 0B/0A. Point C defines the least-cost combination of inputs that produces (y_1^*, y_2^*) (i.e. the point where the marginal rate of technical substitution is equal to the input price ratio w_2/w_1). To achieve the same level of cost (i.e. expenditure on inputs), the inputs would need to be further contracted to point D. The cost efficiency (CE(y, x, w)) is defined by 0D/0A. The input allocative efficiency ($AE_I(y, w_2, w_1)$) is subsequently given by CE(y, x, w)/TE_I(y, x), or 0D/0B in Figure 3 (a).

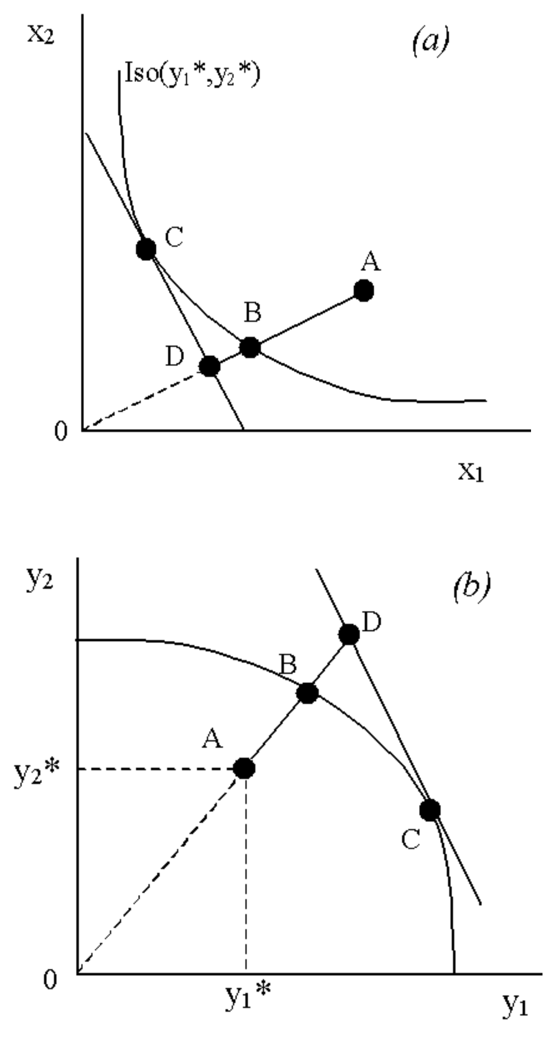


Figure 3 Input (a) and Output (b) Oriented Efficiency Measures

The production possibility frontier for a given set of inputs is illustrated in Figure 3(b) (i.e. an output-orientation). If the inputs are used efficiently by the producer, the output produced at point A can be expanded to point B. Hence, the output oriented measure of technical efficiency ($TE_O(y, x)$), can be given by 0A/0B. This is only equivalent to the input-oriented measure of technical efficiency under conditions of constant returns to scale. While point B is technically efficient, in the sense that it lies on the production possibility frontier, higher revenue could be achieved by producing at point C (the point where the marginal rate of transformation is equal to the price ratio p_2/p_1). In order to maximize revenue, more of y_1 and less of y_2 should be produced. To achieve the same level of revenue as at point C while maintaining the same input and output combination, output needs to be expanded to point D. The revenue efficiency (RE(y, x, p)) is given by 0A/0D. Output allocative efficiency ($AE_O(y, w_1, w_2)$) is given by $RE(y, x, w)/TE_I(y, x)$, or 0B/0D in Figure 3(b). This dissertation focuses on the technical efficiency of agricultural production. Other measures of efficiency discussed above are interesting topics for potential future research.

The stochastic production frontier

The stochastic production frontier models were introduced by Aigner, Lovell, and Schimidt (1977) and Meeusen and van den Broeck (1977) simultaneously, motivated by the idea that deviation from the production frontier may not be completely under the control of producers. They account for technical inefficiency, measurement error and random shocks outside the control of producers to affect output such as weather, as well as the combined effects of unspecified input variables in the production function. The stochastic production frontier model is appealing because in principle the contribution of variation in technical efficiency to output can be separated from impacts on output of shocks due to vagaries of the weather and just plain luck.

Consider a production function

(6-1) $y_i = f(x_i;\beta)$ i=1,2,…,N

where y_i is the scalar output of producer i, x_i is a vector of N inputs used by producer i, β is a vector of technology parameters to be estimated. The farm household attempts to maximize the observed output (y_i) produced by inputs (x_i), given technology and circumstances. $f(x_i;\beta)$ is the production frontier which is deterministic and common to all producers. Usually, observed output is smaller than frontier output $f(x_i;\beta)$ because of technical inefficiency. To capture technical inefficiency, the production function can be rewritten as:

(6-2) $y_i = f(x_i;\beta)\cdot TE_i$

where TE_i is the output-oriented technical efficiency of producer i. Observed output y_i falls short of frontier output $f(x_i;\beta)$ (which is also called maximum feasible output) due to technical inefficiency. TE_i is defined as the ratio of observed output to maximum feasible output given the technology and circumstances:

(6-3) $TE_i = \dfrac{y_i}{f(x_i;\beta)}$

y_i reaches the maximum value of $f(x_i;\beta)$ if and only if TEi=1. TEi<1 when the observed output y_i fails to satisfy the frontier output $f(x_i;\beta)$.

Equation (6-2) is called a deterministic production frontier. Estimation of technical efficiency can be estimated using the deterministic production frontier. However, in addition to technical inefficiency, there are other random shocks affecting observed output such as bad weather, uncertainties in the market situation and other noise that is not under the control of a producer. The deterministic production frontier ignores the effect of random shocks on the production process and runs the risk of improperly translating unmodeled environmental variation into variation in technical inefficiency. To capture measurement error and noise other than technical inefficiency, a stochastic production frontier, which incorporates producer-specific random shocks, is specified as:

$$(6\text{-}4) \quad y_i = f(x_i;\beta)\cdot\exp(v_i)\cdot TE_{i,} i = 1,....I ,$$

$\exp(v_i)$ is assigned to capture the effect of random shocks on each producer, [$f(x_i;\beta)\cdot\exp(v_i)$] is the stochastic production frontier. With this specification, equation (6-3) becomes

$$(6\text{-}5) \qquad TE_i = \frac{y_i}{f(x_i;\beta)\cdot\exp(v_i)}$$

which defines technical efficiency as the ratio of observed output to maximum feasible output in an environment characterized by $\exp(v_i)$. y_i reaches its maximum feasible value of $\left[f(x_i;\beta)\cdot\exp(v_i)\right]$ if and only if TE_i=1. Otherwise, TE_i<1 provides a measure of the shortfall of observed output from maximum feasible output in an environment characterized by $\exp(v_i)$, which is producer-specific. In logarithmic form, equation (6-4) can be written as:

$$\text{(6-6)} \qquad \ln y_i = \ln[f(x_{ni}, \beta)] + \varepsilon_i = \ln[f(x_{ni}, \beta)] + v_i - u_i$$

u_i is the nonnegative technical inefficiency component of the error term. v_i is the two-sided "noise" component, accounting for random factors. The noise component v_i is assumed to be independently and identically distributed (iid) and symmetric, distributed independently of u_i. The error term $\varepsilon_i = v_i - u_i$ is not symmetric, since u_i is nonnegative. The ultimate goal of estimation of the frontier model is to obtain the producer-specific inefficiency u_i, which requires separate estimates of v_i and u_i drawn from estimates of ε_i for each producer. This entails distributional assumptions on the two error components. A few distributional assumptions have been proposed in empirical work such as normal-half normal, normal-gamma, normal-exponential and normal-truncated normal. The following analysis of stochastic production frontier is based on the normal-half normal assumption, which has been employed frequently in empirical work for a long time.

The Normal-Half Normal Stochastic Frontier Model

Consider the stochastic production frontier given in equation (6-7), we make the following distributional assumptions:

(i) v_i ~ iid N (0, σ_v^2)[2]

(ii) u_i ~ iid N$^+$ (0, σ_u^2), that is nonnegative normal

(iii) v_i and u_i are distributed independently of each other, and of the regressors.

The density function of u≥0 is given by

$$(6\text{-}7) \qquad f(u) = \frac{2}{\sqrt{2\pi}\sigma_u}\exp(-\frac{u^2}{2\sigma_u^2})$$

The density function of v is given by

$$(6\text{-}8) \qquad f(v) = \frac{1}{\sqrt{2\pi}\sigma_v}\exp(-\frac{v^2}{2\sigma_v^2})$$

Under the independence assumption, the joint density function of u and v is the product of their individual density function, which is given as

$$(6\text{-}9) \qquad f(u,v) = \frac{2}{2\pi\sigma_u\sigma_v}\exp(-\frac{u^2}{2\sigma_u^2} - \frac{v^2}{2\sigma_v^2})$$

since $\varepsilon_i = v_i - u_i$, the joint density function of u and ε is

$$(6\text{-}10) \qquad f(u,\varepsilon) = \frac{2}{2\pi\sigma_u\sigma_v}\exp(-\frac{u^2}{2\sigma_u^2} - \frac{(\varepsilon+u)^2}{2\sigma_v^2})$$

[2] It is popular to assume the random variable v to be normally distributed with zero mean. v may be heteroscedastic and the model can also be estimated by LIMDEP 8.0. LIMDEP Econometric Modeling Guide v.2, E24-2.

The marginal density function of ε is obtained by integrating u out of $f(u,\varepsilon)$, which yields

$$
\begin{aligned}
f(\varepsilon) &= \int_0^{\infty} f(u,\varepsilon)\,du \\
&= \frac{2}{\sqrt{2\pi}\,\sigma}.[1-\Phi(\frac{\varepsilon\lambda}{\sigma})].\ \exp(-\frac{\varepsilon^2}{2\sigma^2}) \qquad \text{(6-11)} \\
&= \frac{2}{\sigma}.\phi(\frac{\varepsilon}{\sigma}).\Phi(-\frac{\varepsilon\lambda}{\sigma})
\end{aligned}
$$

where $\sigma=(\sigma_u^2+\sigma_v^2)^{1/2}$, $\lambda=\sigma_u/\sigma_v$, and $\Phi(.)$ and $\phi(.)$ are the standard normal cumulative distribution and density functions. λ is an indicator of the relative variability of the two sources of variations. If the value of λ is closer to zero, the symmetric error term dominates the variation between the frontier (maximum reachable) level of output and the observed level of output, that is, the divergence between the observed and the frontier levels output is dominated by random factors outside the control of the producer. Otherwise, the more λ is greater than one, the one-sided error component dominates the symmetric error term in the determination of ε, which means that the more the divergence is dominated by variation coming from technical inefficiency.

The marginal density function $f(\varepsilon)$ is asymmetrically distributed, with mean and variance

$$
\begin{aligned}
E(\varepsilon) &= -E(u) = -\sigma_u\sqrt{\frac{2}{\pi}} \\
& \qquad \text{(6-12)} \\
V(\varepsilon) &= \frac{\pi-2}{\pi}\sigma_u^2+\sigma_v^2
\end{aligned}
$$

Lee and Tyler (1978) proposed the mean technical efficiency of all producers to be:

$$E(\exp\{-u\}) = 2[1-\Phi(\sigma_u)].\exp(\frac{\sigma_u^2}{2}) \tag{6-13}$$

The log likelihood function for a sample of N producers is

$$\ln L = -(\frac{N}{2})(\ln 2\pi + \ln \sigma^2) + \sum_i [\ln \Phi(-\frac{\varepsilon_i \lambda}{\sigma}) - \frac{1}{2}(\frac{\varepsilon_i}{\sigma})^2] \tag{6-14}$$

The log likelihood function can be maximized with respect to the parameters to acquire maximum likelihood estimates of all parameters, which are consistent as N → + ∞.

Once the parameters are estimated, the next step is to obtain estimates of the technical efficiency of each producer. We have estimates of $\varepsilon_i = v_i - u_i$, which obviously contain information on u_i. Information ε_i contains concerning u_i can be obtained from the conditional distribution of u_i given ε_i. Jondrow, Lovell, Materov and Schmidt (1982) showed that if $u_i \sim N^+(0,\sigma_u^2)$, the conditional distribution of u given ε is

$$\begin{aligned} f(u \mid \varepsilon) &= \frac{f(u,\varepsilon)}{f(\varepsilon)} \\ &= \frac{1}{\sqrt{2\pi}\sigma_*}.\exp[-\frac{(u-\mu_*)^2}{2\sigma_*^2}] \Big/ [1-\Phi(-\frac{\mu_*}{\sigma_*})] \end{aligned} \tag{6-15}$$

where $\mu_* = -\varepsilon\sigma_u^2/\sigma^2$ and $\sigma_*^2 = \sigma_u^2\sigma_v^2/\sigma^2$. Since $f(u \mid \varepsilon)$ is distributed as $N^+(\mu_*,\sigma_*^2)$, the mean of this distribution is given by

$$E(u_i \mid \varepsilon_i) = \mu_{*i} + \sigma_* . [\frac{\phi(-\mu_{*i}/\sigma_*)}{1-\Phi(-\mu_{*i}/\sigma_*)}]$$

(6-16)

$$= \sigma_* . [\frac{\phi(\varepsilon_i \lambda/\sigma)}{1-\Phi(\varepsilon_i \lambda/\sigma)} - (\frac{\varepsilon_i \lambda}{\sigma})]$$

Once information of u_i are obtained, estimates of the technical efficiency of each producer can be obtained from

(6-17) $TE_i = \exp(-\hat{u}_i) = \exp[-E(u_i \mid \varepsilon_i)]$

6.3 Econometric Procedures and Discussion of Data

6.3.1 Estimation Strategy

The empirical approach involves two-stage estimation. First, I fit the production frontiers to derive household-specific technical efficiency. Then I regress off-farm labor supply of the operator on technical efficiency and other relevant characteristics using a Tobit model. A few econometric concerns emerge in such a strategy. Finite sample bias is quite possible even using an asymptotically unbiased estimator. The problem inherent to the multi-step procedure is that any bias in the early stage would be propagated to the second stage, potentially creating errors in variables. Asymptotic theory is likely to yield a poor approximation of the distribution of test statistics derived from a sequential estimator, compromising inference with respect to parameters of interest. A bootstrap bias reduction procedure is employed to address the problems. Goodwin (1993) proposed an analytical simplified approach for estimating standard errors in a simultaneous-equation Tobit model (bootstrapped two-stage estimator). He simulated a data series and evaluated alternative estimators (standard OLS and MLE Tobit estimates, Nelson and Olsen's two-stage, Amemyia's GLS estimator, and the proposed two-stage estimator). Goodwin found that each estimator provides consistent estimates except the standard OLS and ML Tobit which revealed strong bias and emphasized the pitfalls of ignoring simultaneity. He concluded that bootstrapping provides a valid alternative for estimation of covariance matrices for systems of simultaneous equations Tobit regression models. The bootstrap not only yields a consistent estimator of the distribution of a statistic, but also reduces the finite-sample bias of an asymptotic estimator. I first estimate the full model using conventional, asymptotic distribution theory. Then I randomly sample with replacement from the data and reestimate the full, sequential model with the new sample and repeat the reestimation for 500 replicates.

6.3.2 Empirical Stochastic Frontier Model

We write equation (6-6) as

$$\text{(6-18)} \quad \ln y_i = \beta_0 + \sum_n \beta_n \ln x_{ni} + v_i - u_i ,$$

$\ln y_i$ is specified to be log of the value of production output harvested by the ith household. x_{ni} is a vector of n inputs employed by the ith household including the contracted land area, the total amount of farming labor (in annual hours) from family and hired labor, the total amount of fertilizer used, the total cost of seeds, manure, insecticides, gas and electricity used in agricultural production, etc. The farm household attempts to maximize the observed output value (lny) produced by inputs (lnx), given technology and other production circumstances.

In much previous research where stochastic frontiers were applied to understand producer specific technical inefficiency, efforts have also been put to investigate the determinants of technical inefficiency. It has been shown that sources of technical inefficiency are concerned with exogenous factors such as producers' characteristics, location characteristics and so on. The model to determine technical inefficiency sources in the stochastic frontier of equation (6-18) is defined by

$$(6\text{-}19) \quad u_i = \delta_0 + \sum_m \delta_m x_{mi} + \omega_i \ ,$$

where subscript i represents the i[th] household. x_{mi} represent a vector of m exogenous explanatory variables hypothesized to associate with technical efficiency, including household characteristics such as the average age of farm workers in the household, the ratio of male farmers to the farm workers in the household and dummy variables about village policy (e.g. if the village supply farming service such as irrigation, purchasing HYV and fertilizer and etc).

To incorporate the effects of the exogenous factors on technical inefficiency, I directly include the exogenous variables (x_{mi}), which are assumedly associated to technical inefficiency, in the estimation of the production frontier. Exogenous variables (x_{mi}) are assumed to improve or reduce output value through decreasing or increasing technical inefficiency. Combining equation (6-18) and equation (6-19), the model is specified as

$$(6\text{-}20) \quad \ln y_i = \beta_0 + \sum_n \beta_n \ln x_{ni} + \sum \gamma_m x_{mi} + v_i - u_i$$

In the empirical part, I will derive household technical efficiency by using both equation (6-18) and equation (6-20). Equation (6-20) will serve as the reference for empirical specification, since it includes more variables.

6.3.3-1 Crop Production Technical Efficiency

Following the analysis above, an approximate crop production model is specified as:

$$\begin{aligned}(6\text{-}21)\quad & \ln Q = \beta_0 + \beta_1 \ln C + \beta_2 \ln H_c + \beta_3 \ln V + \beta_4 \ln M + \\ & \beta_5 \ln T + \gamma_1 Age + \gamma_2 Male + \gamma_3 Edu + \gamma_4 High + \gamma_5 Low \\ & + \gamma_6 Cont + \gamma_7 Land + \gamma_8 Sev + \in\end{aligned}$$

Three categories of variables have been considered in the model; the output variable, conventional inputs and exogenous factors assumed to affect efficiency. The definitions of the variables are shown in table 6-1 and summary statistics are reported in Table 6-2(1). The dependent variable Q is defined as the value (in Yuan) of crop output of the household. This variable is a measure of crop production valued at the actual price at which it is sold (either the market price or state price) and the home consumption and stock are valued at the state price. Cultivated area for cropping (C), labor input (H_c), variable inputs (V, including seed, pesticides, fertilizers and manure), value of owned modern farm implements (M), and traditional farm tools (T) are the variables considered representing the conventional inputs, which are hypothesized to be positively related to output value. The labor input is measured as the annual hours worked in crop cultivation by all household members and non-household members who worked for the household. The coefficients ($\beta_1 \dots \beta_5$) represent the elasticity of the conventional inputs respectively. The magnitudes of these coefficients would give us an idea about what roles the conventional inputs play in crop production. HIGH and LOW are used to adjust for land quality, which are expected to have positive and negative effects on efficiency, respectively.

The ratio of male farmers and average age of farmers in the household, education of the operator, information about land readjustment, help offered by the village with farm work and presence of grain procurement contract are considered as exogenous variables affecting efficiency. The effect of age of farmers on efficiency is expected to be either positive or negative; there is an experience effect potentially increasing efficiency as age increases while old age implies a decreasing capacity to do work and to adopt new inputs and technologies. The effect of the ratio of male farmers to total number of farmers depends on how much women are involved with farm work. This effect is anticipated to be uncertain. On one hand, women may be more involved with housework; on the other hand, men may be more involved in off-farm labor markets. Education of the operator is anticipated to have a positive effect on farming efficiency. The presumption is that a better-educated operator is better equipped with information about inputs and technologies. Two dummy variables for village land readjustment policies and services offered by the village are anticipated to improve efficiency. The effect of procurement contracts depends on the contemporary grain market: it might have an encouraging effect if the fixed price is higher than the market price; it might have a discouraging effect if the fixed price is lower than the market price.

6.3.3-2 Agricultural Production Technical Efficiency

Besides field crop production, Chinese farmers also engage in other agricultural production activities such as raising livestock and fish, growing vegetables and fruits, which has been an important part of farmers' consumption as well as sources of income. The summary statistics of the variables are reported in Table 6-2(2).

The household agricultural production is specified approximately as:

$$\text{(6-22)}\quad \begin{aligned} &\ln y = \beta_0 + \beta_1 \ln F + \beta_2 \ln H_F + \beta_3 \ln I + \beta_4 \ln T + \gamma_1 Age + \\ &\gamma_2 Male + \gamma_3 Edu + \gamma_4 High + \gamma_5 Low + \gamma_6 Cont + \gamma_7 Land + \gamma_8 Sev + \in \end{aligned}$$

which is similar to the crop production model specified as equation (6-21). The differences lie in the dependent variable and conventional inputs. For equation (6-21), the dependent variable y is defined as the value of aggregate agricultural output of the household (which includes crop output value as well as output value of vegetables, fruits, livestock and fish) at actual prices. Naturally, conventional inputs refer to the inputs for all agricultural production mentioned above. Total farmland owned by the household (F) includes cultivated area for crops and area for non-crop agricultural production. Total labor input (H_F) includes labor input for crop production as well as for other farming activities. I denotes the worth of all capital investment in household agricultural production. Traditional farm tools (T) is also included since crop production is an essential part of household agricultural production. All the exogenous variables assumed to affect crop production are anticipated to affect the whole household agricultural production.

6.3.4 Off-Farm Labor Supply and Technical Efficiency

Following the theoretical model developed in chapter 4, if we hold the total amount of labor supplied constant, a multiple job holding farm operator allocates his time between farm work and off-farm work until the value of the marginal product of farm labor is equal to the off-farm wage rate. An increase in the price of farm output or an increase in on-farm labor productivity implies a higher implicit farm wage and thus will result in more labor being supplied to the farm and less to off-farm activities. Likewise, an increase in the off-farm wage rate would result in a lower level of farm employment. Chapter 4 investigated the relationship between farming efficiency and off-farm labor supply. A standard, reduced-form labor supply equation was used to relate hours of off-farm work to on-farm productivity (technical efficiency), and other variables that are conceptually relevant to the farm operator's labor supply decisions such as variables pertinent to wages, and farm and operator characteristics potentially relevant to work attitudes and the costs associated with off-farm work. The corner solutions are implied if farmer operators only work on the farm (off-farm labor supply is zero), raising the issue of censoring or selection issues. In the analysis, a significant proportion of the farm operators did not work off-farm. The censoring is recognized through the adoption of the Tobit model, which has been popularly used to estimate labor supply equations with work hours as the dependent variable because hours are clustered at zero for non-workers. In this chapter, a more sophisticated measure of farming efficiency is adopted while the empirical labor supply function and other relevant variables are specified in the same way as in Chapter 4. The empirical labor supply function of the operator is specified as:

$$\begin{aligned}(6\text{-}23)\quad & H = \alpha_0 + \alpha_1 TE + \alpha_2 Male + \alpha_3 Edu + \alpha_4 Train + \alpha_5 Age + \alpha_6 Kid \\ & + \alpha_7 Farm + \alpha_8 Crop + \alpha_9 Ncrop + \alpha_{10} DETASE + \alpha_{11} Worth + \\ & \alpha_{12} Nlainc + \alpha_{13} Livst + \alpha_{14} LaTr + \alpha_{15} NagL + \alpha_{16} Bus + \alpha_{17} En + \varepsilon\end{aligned}$$

The dependent variable is defined as annual hours supplied for off-farm employment (H). In addition to technical efficiency, other independent variables include individual characteristics such as age and human capital variables; household production characteristics and locational characteristics. Age of the operator is included as an indicator of the preferences of individuals such as different views and attitudes about employment. It is anticipated that young people are more active in off-farm labor markets and thus age is expected to be negatively related to off-farm labor supply. Years of formal education and vocational training are used as indicators of an individual's stock of human capital. The effects of human capital on the off-farm labor supply include both direct and indirect effects. If human capital improves an individual's performance in farming activities, then it increases the shadow value of labor. A better-educated person is assumed to have better opportunities in the off-farm labor market. A dummy variable, MALE, is included to investigate gender effects in the off-farm labor market. Male farmers are expected to be more involved with off-farm employment, because females are traditionally more involved with housework.

The presence of young children has been shown to have important effects on the off-farm labor supply. The effects of children on the labor supply by men are uncertain. Children may require childcare time by the husband. On the other hand, there may be further pressure for additional income for larger families. Female farmers, who traditionally take more responsibilities for homemaking and childcare, usually find the number of children to be inversely related to the hours worked off-farm. FARMLAND is included as a measure of farm scale. The ratio of cropping area to total farmland (CROP_AREA), the ratio of area for vegetables and fruits to total farmland (NONCROP_AREA), and the ratio of income from livestock to the ratio of income from cropping (LIVESTOCK_CROP) are used to measure differences in farm activities, which may affect off-farm labor supply through both the time constraint and the budget constraint. HIGH (LOW) are the ratios of high (low) quality crop cultivation area of total cultivated area of the household. They are included to adjust for differences in land quality. NONLABORINCOME is included to capture the effects of exogenous non-wage income on the consumption of leisure. If leisure is a normal good, higher levels of income from non-labor sources would result in fewer hours of off-farm employment. DEBT_ASSET is used to capture the leverage effect. The overall net worth of the farm household is also included. Farmers who are less financially restricted to invest in farming are expected to work fewer hours off-farm.

The number of buses passing by daily is considered to capture the effect of the transportation system. Farmers located in areas with better transportation are expected to be more active in the off-farm labor market. NONAGLABOR_TOTALLABOR is the ratio of the village labor force participating in nonagricultural activities to the total labor force in the village, which is included to measure the development level of local off-farm labor market. ENTERPRISE is a dummy variable having a value of one if the village has at least one rural enterprise. Rural enterprises are supposed to grant more off-farm employment opportunities to local farmers. LAND_TRANSFER is a dummy variable used to catch the effects of local village institutions, having a value of one if the village regulation allows for completely free land transfer. When farmers are allowed to transfer their land freely, they have more freedom to leave farming if they want to, therefore have more active access to off-farm labor market. LAND_TRANSFER is assumed to have positive effects on the supply of off-farm labor.

6.4 Estimation Results and Discussion

First of all, I derive household technical efficiency (both crop production technical efficiency and agricultural production technical efficiency) referring to equation (6-18) and equation (6-20), and inspect their relationship with off-farm labor supply. The results are very similar qualitively. The reports below are stated referring to equation (6-20).

6.4.1 Crop Production Technical Efficiency and Off-Farm Labor Supply

The initial estimation results about crop production technical efficiency and off-farm labor supply are reported in Table 6-3(1) and Table 6-3(2). Using initial estimates as starting value, I randomly sample with replacement from the data and reestimate the full, sequential model with the new sample and repeat the reestimation for 500 replicates. The bootstrap results are reported in Table 6-4(1) and Table 6-4(2). The bootstrap results are qualitatively identical to the initial estimates.

The estimation of stochastic production functions provides estimates of the elasticity of crop income with respect to labor, cultivated land and variable inputs, which are 0.03, 0.61 and 0.31 respectively. The small elasticity of crop income with respect to labor, which is statistically insignificant, suggests a very low value of marginal product of labor in crop production. It implies that the change of crop income is not sensitive to a change of hours supplied for crop production. It seems contradictory to the fact that crop production in China is traditionally labor intensive. The explanation may be that the Chinese farm households supplied more than enough hours for crop production, given the enormous agricultural labor force and limited non-agricultural employment opportunities. The result suggests the surplus labor in the household level crop production. The elasticities with respect to cultivated area and variable inputs are small, but they are statistically significant, indicating that the change of crop income is relatively more sensitive to the change of cultivated area and variable inputs. The relatively larger elasticity of crop income with respect to cultivated land suggests that consolidation of cultivated land will enhance crop production and increase income from crop cultivation. This result is consistent with the result in chapter 4, implying the necessity of a free agricultural land market. Under the current land allocation system, each agricultural household has a fixed amount of farmland according to the household size, which hinders efficiency improvement of households who want to concentrate on crop production. A free agricultural land market will improve the efficiency of land allocation and consequently help to raise efficiency of crop production. The elasticity of crop income with respect to variable inputs implies that increased use of variable inputs such as HYV, fertilizer and pesticides will help to increase crop income. Modern tools and traditional farm tools both have a positive sign, but neither is economically or statistically significant. The reason why modern tools have no significant effect on crop income is not discernible. It may be because modern tools are not used efficiently at their full scale. LOW has a strong negative effect on crop income, which is intuitive since low quality land is less productive. Education of the operator has a slight positive effect on crop income. Better education is likely to improve the ability of farmers to understand and adopt new technologies and process market information.

The ratio of male farmers to the total farm workers in the household and the average age of farm workers don't show significant effects on crop income, indicating that age and gender don't play a large role in crop production. The grain procurement contract variable has a negative sign, but the coefficient is trivial in economic term and is insignificant statistically, suggesting that the grain procurement contract didn't affect technical efficiency of crop production in 1994. LAND_INFORMATION has a significant positive effect on crop income. It can be explained that once farm operators are secure about their future land use rights, they are more motivated to make land improvement. This suggests that farm operators would further benefit from more apparent and flexible policies and further institutional reforms. FARMSERVICE has a significant positive effect on crop income, showing that collective work played an important role in household level crop production. I didn't distinguish between help on market behavior (buying HYV, fertilizer and other inputs) and production behavior (plowing, irrigation, harvesting and peeling). If help on market behavior played an important role, it might suggest that farm operators who were just released from centrally planned control need to adjust themselves to more efficient market behavior.

The summary statistics of the initial estimates of crop production technical efficiency (denoted as TE_c) are reported in Table 6-3(1), and the summary statistics of the bootstrap estimates are reported in Table 6-4(1). The analysis shows that the mean of crop production technical efficiency of 538 households is 0.58, the minimum is 0.11 and the maximum is 0.91. About 52.6 percent of the households (283) were found to have an efficiency level above 0.59, and 12.8 percent of the households (69) were found to have an efficiency level above 0.75. The value of λ is 1.703, suggesting that the divergence between the observed and the frontier levels of output is dominated by variability emanating from technical inefficiency. This analysis suggests that for most households there is some room for efficiency improvement. Based on the analysis above, technical efficiency could be improved from a few aspects: enhancing specific agricultural education, increasing investments of variable inputs such as HYV seeds, fertilizer and etc, improving the quality of cultivated land, providing more apparent and flexible policies and reforming the land system to entail free agricultural land markets. The interest of this study is how variation of household technical efficiency is related to the operator's off-farm work hours? Does off-farm labor supply decrease technical efficiency by pulling effort away from crop production as the theoretical expectation?

The initial and bootstrap estimation results of the off-farm labor supply equation with TE_c are respectively shown in Table 6-3(2) and Table 6-4(2). In light of the censoring, the coefficients don't directly represent marginal effects. The marginal effects can be obtained by scaling the coefficients by the proportion of observations that are noncensored (0.66 in this case) Table 6-3(2) reports marginal effects of selected variables. First of all, I found a significant positive relationship between annual hours supplied for off-farm work and crop production technical efficiency. This seemingly surprising result is a reflex of Chinese rural economic situation in the middle 1990s. With the improvement of the productivity of crop cultivation, which is contributed by adoption of new technology and increased investment level of variable inputs such as HYV and fertilizers, more labor force have been transferring out of crop cultivation. However, labor time pulled away from crop production did not negatively affect the productivity due to the enormous labor input. At the same time, the land allocation system impeded efficient land allocation. With the absence of a free land market, the current land allocation system set a scale limit for household crop production by fixing the amount of land equally available to each household. It is natural that the more efficient the households are in crop production, the more labor the operators can spare for off-farm employment. It is consistent with the result of the estimation of crop production technical efficiency: the inelasticity of crop income with respect to labor suggests a very low value of marginal product of labor in crop production, which serves to diminish the amount of labor used in crop production. According to the theoretical model, this process will continue until the value of the marginal product of labor in crop production equals the value of marginal product of labor in other employment, such as off-farm work or agricultural activities other than crop production

Formal education and vocational training demonstrate significant positive effects on off-farm labor supply. One more year of education and one more month of vocational training induce respectively 91.15 and 16.66 more hours of off-farm labor supply. The substantial positive effects of human capital confirm the existence of off-farm labor markets in the area. Males tend to supply more labor to off-farm employment, suggesting a significant gender difference in the off-farm labor market. Older people tend to provide less labor to off-farm employment. One-year older in age results in 14.48 fewer hours of off-farm work. It may be because younger people are less keen on farming work but are more attracted to off-farm work and they have better opportunities in off-farm labor markets. The number of children under the age of 10 years in the household has a negative sign, but it is not statistically significant.

The ratio of DEBT_ASSET doesn't show a significant effect on off-farm labor supply. The imperfection of rural credit markets in China might explain this result. There are state-owned agricultural banks, rural credit cooperatives and other banks and foundations available in every town, but it is not a popular practice for Chinese farmers to finance their farming investment due to huge transaction costs. One reason is that farmers don't own the land thus they have no collateral. Consequently, leverage effects do not have an important influence on off-farm labor supply. The coefficient of NONLABORINCOME is statistically insignificant, though it has a negative sign. It suggests that the effect of income from non-labor resources on off-farm labor supply is negligible. Leisure may not be a normal good for the farm operators. Net worth shows a significant positive effect. The population elasticity of annual off-farm work hours with respect to net worth at the mean is 0.279. Though this effect is small, it is statistically significant as well as significant economically. Research in developed countries has found that net worth of the farm household has a negative influence on off-farm labor supply due to a lower degree of financial pressure, which is consistent with a backward bending labor supply function (Goodwin and Mishra). The positive effect of net worth and the negligible effect of non-labor income suggest that the labor supply curves of Chinese farmers are forward rising where the substitution effect dominates over the income effect. It also likely reflects that households involved with off-farm employment are in a better economic situation, considering the low marginal value product in crop production.

FARMLAND is strongly and inversely related to the operators' labor supply. At the same time, CROP_AREA has a strong negative effect while NONCROP_AREA doesn't show a significant effect. With a larger farm and more intense crop cultivation, the operator may spend more time on farm work and less time on off-farm activities. With crop cultivation as the major subsistence activity for Chinese rural households, non-crop (such as fruits and vegetables) production has mainly been a supplement for the self-sufficient household economy and thus shows no significant influence on off-farm labor supply. The effect of LIVESTOCK_CROP on off-farm labor supply is not significantly different from zero. It is not surprising since our data only include small-scale livestock operations but not large scale commercialized livestock operation, which may require year-round labor.

The coefficient of the dummy variable ENTERPRISE is not significantly different from zero, indicating that the presence of rural enterprises is not an important source for off-farm employment in the sample area. The number of buses passing by the village has a slight positive effect. A surprising result is that the ratio of non-agricultural labor force to the total labor force in the village has a slight negative effect on off-farm labor supply. One would anticipate that a higher ratio of NONAGLABOR_TOTAL would suggest a more developed local off-farm labor market and better job options. This negative relationship may reflect a surplus labor supply in the off-farm labor market -- the fewer hours the farm operators supply to the off-farm employment, the more employment opportunities there are for the total labor force which consequently results in a higher ratio of NONAGLABOR_TOTAL. Unexpectedly, BUSES doesn't show a significant effect. Finally, the permission of free land transfer in the village strongly encourages off-farm labor supply. If the farm operator can transfer the household's farmland or part of it to other households, the opportunity cost of his participation in the off-farm labor market is reduced, therefore the farm operator would, if he prefers, supply more labor to his off-farm employment. If the village forbids land transfers among rural households, the farm operator would be less interested in his off-farm work due to a high opportunity cost.

6.4.2 Agricultural Production Technical Efficiency and Off-Farm Labor Supply

As defined in 6.3.2, agricultural production includes not only crop cultivation but also non-crop agricultural activities such as livestock production and non-crop activities. A different marginal value product of labor for agricultural production is anticipated due to the different requirements of labor supply for different production activities and the different requirements of investment of other production factors. A different technical efficiency level is expected and it is expected to have a different effect on off-farm labor supply. Similarly, using the initial estimates as the starting value, I randomly sample with replacement from the data and reestimate the full, sequential model with the new sample and repeat the reestimation for 1000 replicates. The initial estimates and the bootstrap estimates are very similar.

The initial and bootstrap estimates of agricultural production technical efficiency are reported in Table 6-5(1) and Table 6-6(1) respectively. The elasticity of income from agricultural production with respect to labor, total farmland and capital investment are 0.17, 0.33 and 0.44 respectively, which are all statistically significant. The elasticity of income with respect to labor, though small, doesn't suggest so low a value of marginal product of labor as it did for crop production. The mean of the marginal return of labor in household agricultural production is 1.13. This suggests that expansions of agricultural activities other than crop cultivation absorbed some rural labor forces that are spilled over by crop production. In line with the previous result, the elasticity of income with respect to farmland suggests that consolidation of land will increase rural households' agricultural income. Once again, it suggests that the absence of a free agricultural land market results in an agricultural labor surplus of very low income and large underemployment. The elasticity of crop income with respect to capital investment suggests that a ten percent investment increase induces 4.4 percent income increase. The traditional farm tool variable has a slight positive effect. It comes naturally that LOW has a slight negative effect on total income since it showed a strong negative effect on crop income. The effect of education of the operator is not significantly different from zero.

The ratio of male farmers to the farm workers in the household and the average age of farm workers don't show significant effects, which indicates that age and gender don't play a large role in other agricultural activities as well as in crop production. We observed in section 6.4.1 that the existence of a grain procurement contract didn't affect crop production technical efficiency in 1994. However, the grain procurement contract showed a positive effect on the total farm income. It may suggest that households with the fixed-price contract could shift more time to other agricultural activities since they didn't need to worry about market crop prices and it reduces transaction costs. LAND_INFORMATION and FARMSERVICE showed significant positive effects on total agricultural income, consistent with our earlier findings

The analysis of agricultural production technical efficiency (denoted as TE) shows that the mean of agricultural production technical efficiency of 602 households is 0.725, the minimum is 0.31 and the maximum is 0.92. About 81 percent of the households (489) were found to have an efficiency level above 0.87, and 15.78 percent of the households (95) were found to have an efficiency level above 0.79. The value of λ is 0.80, suggesting that the divergence between the observed and the frontier levels of output is dominated by random factors outside the control of the producer. The average efficiency level of agricultural production is higher relative to the average efficiency level of crop production. The kernel density estimation shows that crop production technical efficiency is more sparsely distributed. The reason for this phenomenon is of future research interest.

The initial estimation results of the off-farm labor supply equation with TE are reported in table 6-5(2) and the bootstrap results are reported in table 6-6(2). Similarly, the coefficients don't directly represent marginal effects in light of the censoring. An approximation to the marginal effects can be obtained by scaling the coefficients by the proportion of observations that are noncensored (0.67 in this case). The marginal effects of selected variables are reported in table 6-5(2). Firstly, agricultural production technical efficiency has a negative sign, but it is not significant. It is in line with the finding in Chapter 4. The reason is due to the existence of labor surplus in the household level.

Most of other variables exhibit similar effects to the earlier findings. Formal education and vocational training demonstrate significant positive effects on off-farm labor supply. One more year of education and one more month of vocational training induce respectively 85.50 and 17.98 more hours of off-farm labor supply. The substantial positive effects of human capital confirm the existence of off-farm labor markets in the area. Male has a large positive impact on off-farm labor supply, showing a significant gender difference. Age again shows a significant negative effect, showing one-year older in age results in 16.15 fewer hours of off-farm work. Younger people are less keen on farming work but are more attracted to off-farm work and they are more employable in the off-farm labor market. The number of children under the age of 10 years in the household has a negative sign, but it is not statistically significant.

The DEBT_ASSET ratio doesn't show significant effect on off-farm labor supply. As stated earlier, leverage effects do not have an important influence on off-farm labor supply due to the imperfection of rural credit market in China. NONLABORINCOME exhibit a negligible negative effect on off-farm labor supply. Net worth shows a statistically significant positive effect. The population elasticity of annual work hours at the mean is 0.30. In line with the analysis in section 6.4.1, this small effect may suggest a forward bending labor supply curve for Chinese farmers where substitution effect dominates over income effect.

FARMLAND is strongly and inversely related to the operators' labor supply. At the same time, CROP_AREA has a strong negative effect while NONCROP_AREA doesn't show significant effect. With a larger farm and more intense crop cultivation, the operator may spend more time on farm work and less time on off-farm activities. With crop cultivation as the major subsistence activity for Chinese rural households, non-crop (such as fruit and vegetable) growing has been a mere supplement for the self-sufficient household economy and thus shows no significant influence on off-farm labor supply. LIVESTOCK_CROP showed a slight negative effect on off-farm labor supply. This may reflect differences in labor requirements for different agricultural activities. Many livestock operations require year-round labor, which exerts a negative effect on off-farm labor supply. In line with the earlier findings that ENTERPRISE, BUSES and NONAGLABOR_TOTAL don't show significant effects. LAND_TRANSFER has a strong positive effect on off-farm labor supply.

Based on the estimation results, I calculated the marginal return of labor in crop production and the marginal return of labor in agricultural production for each household (see table 6-7). Dividing the crop output value of the household by the labor hours input into crop production gives the average output per hour of labor input. Multiplying the average value product of labor by the elasticity of the labor (0.03) from the estimated model gives the marginal returns of labor. The mean of the marginal return of labor in crop production is 0.33 yuan per hou. Similarly, dividing the agricultural output value of the household by the labor hours input into agricultural production gives the average output per hour of labor input. Multiplying the average value product of labor by the elasticity of the labor (0.16) from the estimated model gives the marginal returns of labor. The mean of the marginal return of labor in agricultural production is 1.13 Yuan per hour. I also calculated the average wage for the operators engaging in off-farm labor market by dividing their annual income from off-farm employment by their annual hours worked for their off-farm job (reports of income from off-farm employment has a large missing value). The mean of average wage is 2.12 yuan per hour. It is obvious that the marginal returns of labor to crop production, agricultural production and off-farm employment are not equal. It confirms the results above that households retain surplus labor in agricultural activities especially in crop cultivation and face constraints in moving labor off the land.

6.5 Conclusions

This paper used a stochastic frontier approach to derive farm household specific agricultural production technical efficiency and crop production technical efficiency; and investigated the relationship between the operator's off-farm labor supply and the two versions of household technical efficiency respectively.

The principal finding is that crop production technical efficiency is positively related to off-farm labor supply and the agricultural production technical efficiency shows no significant effect on off-farm labor supply. The inelasticity of crop income with respect to labor suggests a very low marginal product value of labor. Income from agricultural production is also not sensitive to labor input. The marginal returns to labor in agricultural activities and in off-farm employment are not equal. The marginal product value of labor in the crop production is 0.33 Yuan per hour. The marginal value product of labor in the agricultural production is 1.13 Yuan per hour. The average wage rate in the off-farm labor market is 2.12 Yuan per hour.

The results suggest that surplus labors are retained in household agricultural activities, especially in crop production, due to restrictions on labor mobility. The land allocation system keeps farmland holdings of each household fixed, which consequently precludes large-scale crop production. The more efficient the households are in crop production, the more labor they could supply to off-farm work. The higher value of the marginal product value of labor in agricultural production than in crop production is that Chinese government policies have been focused on grain supply for the population. As the most important sustenance for Chinese farmers, crop production has retained huge labor forces while non-crop agricultural production has been neglected until recently. Diverse non-crop agricultural activities could be greatly encouraged. In general, surplus labor supply exist in the household l agricultural production, restrictions on labor mobility causes its marginal returns of labor lower than the wage rate of off-farm employment.

The land allocation system retains farmers on land—the permission of free transfer of land highly increases off-farm labor supply. Simultaneously, the land allocation system results in the small sizes of the farms, which is a major constraint on raising farm labor productivity. Consolidation of farmland in a smaller number of farms will increase household technical efficiency in agricultural production. A free agricultural land market will benefit farmers from scale effects as well as diminishing labor mobility restrictions and improving farmers' labor allocation efficiency.

Additionally, the Household Registration System hinders migration, which may affect farmers' off-farm labor supply decisions, especially for the area where local off-farm labor markets are not well developed. Since permanent migration is impeded by the policy, it is highly possible that some farmers are willing to settle down for lower returns of labor in agricultural activities so that surplus labor are retained in the agriculture.

The agricultural labor surplus will move off the land into more productive employment once constraints on labor mobility are removed. In theory, if the surplus labor forces in the agriculture move out into higher-paying activities, the marginal returns of the labor remaining will increase until it equals the wage rate of off-farm employment.

Table 6-1. Definition and Measurement of Variables

Variable	Definition
Variables considered for the estimation of TE_c and TE	
Ag_income (Y)	Value of all agricultural products in Yuan
Hrs (H_F)	Annual hours worked on household agricultural production by all members
Farmland (F)	Total farm land of the household in 1994 (Mu[1])
Investment (I)	Value of all capital investment for household agricultural production in Yuan
Farm_tool (T)	Total numbers of tools such as plow and etc.
Crop_income (Q)	Value of crop output in Yuan
Crop_hrs (H_c)	Annual hours worked on crop production by all household members
Cultivated Area	Cultivated area for crop of the household in 1994
Variable_input (V)	Value of variable inputs for crop production in Yuan
Modern_tool (M)	Value of owned farm equipment such as tractor, plump and etc. in Yuan
Aver_age	Average age of household members who worked on farm in 1994
MalefarmerR	The ratio of male to the household members who worked on farm to in 1994
Edu_year	Formal schooling years of the household head
High	The ratio of high quality cultivated area to total cultivated area
Low	The ratio of low quality cultivated area to total cultivated area
Contract	Dummy variable, value one if the household signed procurement contract
Land_information	Dummy variable, value one if the villagers are informed about land adjustment
Farmservice	Dummy variable, value one if the village help farm work
Variable considered for the estimation of off-farm labor supply	
Off_hrs (H)	Annual hours worked off-farm of the household head
Male	Dummy variable, value one if the operator is male
Age	Age of the household head
Training	Months of off-farm job training of the household head
Num_youngkids	Number of children under 10 years old in household
Nonlaborincome	Income from nonlabor resources in Yuan
Networth	Household net worth in 1994 in Yuan
Debt_asset	The ratio of total debts to total assets
Livestock_crop	The ratio of income from livestock to income from crop
Noncrop_area	The ratio of area for non-crop agricultural production to total farm land
Crop_area	The ratio of cultivated area for crop production to total farm land
Land_transfer	Dummy variable, value one if the village allow for free land transfer
Enterprise	Dummy variable, value one if the village have at least one rural enterprise
Buses	Number of buses passing by the village everyday
Nonaglabor_total	The ratio of nonagricultural labor force to the total labor force in the village

[1] 1Mu=0.16 Acres=0.67 Hectares

Table 6-2 (1) Description of the data for TE_c and Off-farm Labor Supply

Variable	Mean	Std. Dev.	Min	Max
Individual and Household Characteristics (n=538)				
Off_hrs	950.91	1090.56	0.00	6840.00
Crop_income	4992.92	5906.15	25.00	44500.00
Crop_hrs	689.60	508.20	40.00	3416.00
Cultivated Area	12.19	12.42	0.20	184.00
Variable_input	2850.54	3594.54	126.60	30157.25
Modern_tool	2728.65	3276.34	1.00	35015.00
Farm-tool	14.23	5.19	4.00	41.00
Contract	0.87	0.33	0.00	1.00
Male	0.97	0.16	0.00	1.00
Age	43.40	11.25	22.00	74.00
Average_age	38.86	9.61	22.00	73.00
MalefarmerR	0.54	0.15	0.20	1.00
Edu_year	6.21	2.55	0.00	12.00
Training	1.06	4.49	0.00	48.00
Num_youngkids	0.52	0.70	0.00	3.00
Nonlaborincome	865.25	2008.56	0.00	20000.00
Livestock_crop	0.71	1.55	0.00	17.90
Networth	29487.9	25783.93	-4605.00	181060.00
Debt_asset	0.05	0.15	0.00	1.40
Farmland	20.88	14.07	2.00	124.00
Noncrop_area	0.05	0.14	0.00	2.03
Crop_area	0.63	0.59	0.10	7.19
High	0.39	0.38	0.00	1.00
Low	0.13	0.21	0.00	1.00
Village Characteristics (n=31)				
Land_transfer	0.71	0.46	0.00	1
Land_info	0.61	0.50	0.00	1
Farmservice	0.84	0.37	0.00	1
Enterprise	0.39	0.50	0.00	1
Buses	21.65	36.86	0.00	144
Nonaglabor_total	0.34	0.20	0.06	0.78

Table 6-2 (2) Description of the data for TE and Off-farm Labor Supply

Variable	Mean	Std. Dev.	Min	Max
Individual and Household Characteristics (n=602)				
Off_hrs	949.73	1077.07	0.00	6840.00
Ag_income	7829.10	7806.79	106.00	62100.30
Hrs	1448.83	972.39	32.00	7024.00
Farmland	20.34	13.91	1.80	124.00
Investment	5470.76	5440.08	38.00	45766.75
Farm-tool	13.78	5.31	1.00	41.00
Contract	0.86	0.35	0.00	1.00
Male	0.97	0.18	0.00	1.00
Age	43.20	11.55	22.00	75.00
Average_age	38.85	10.01	22.00	76.00
MalefarmerR	0.54	0.15	0.20	1.00
Edu_year	6.29	2.58	0.00	13.00
Training	1.04	4.46	0.00	48.00
Num_youngkids	0.52	0.69	0.00	3.00
Nonlaborincome	841.71	1951.75	0.00	20000.00
Livestock_crop	0.66	1.50	0.00	17.90
Networth	28478.83	26051.74	-10603.00	194300.00
Debt_asset	0.07	0.25	0.00	4.27
Noncrop_area	0.52	0.13	0.00	2.03
Crop_area	0.63	0.61	0.01	7.19
High	0.39	0.39	0.00	1.00
Low	0.13	0.22	0.00	1.00
Village Characteristics (n=31)				
Land_transfer	0.71	0.46	0.00	1
Land_info	0.61	0.50	0.00	1
Farmservice	0.84	0.37	0.00	1
Enterprise	0.39	0.50	0.00	1
Buses	21.65	36.86	0.00	144
Nonaglabor_total	0.34	0.20	0.06	0.78

Table 6-3(1) Initial Estimation of Crop Production Technical Efficiency

Variables	Estimate	Std. Error	B/St.Er.	P-value
Lncropincome N=538				
Intercept	4.17	0.48	8.65	0.0000
LnCultivatedarea	0.61	0.05	12.26	0.0000
Lncrophours	0.03	0.05	0.73	0.4661
Lnvariableinputs	0.31	0.04	7.55	0.0000
Lnmoderntool	0.003	0.02	0.19	0.8533
Lnfarmtool	0.04	0.09	0.46	0.6445
High	0.05	0.08	0.63	0.5295
Low	-0.44	0.14	-3.14	0.0017
Education	0.02	0.01	1.54	0.1226
MalefarmerR	-0.007	0.18	-0.04	0.9686
Average age	0.001	0.004	0.23	0.8192
Contract	-0.008	0.09	-0.09	0.9301
Land information	0.26	0.06	4.43	0.0000
Farmservice	0.24	0.07	3.28	0.0010
Log Likelihood		-508.26		
Sigma-squared(v)		0.19		
Sigma-squared(u)		0.56		
Sigma=Sqr[s^2(u)+s^2(v)]		0.87		
Lambda=sigma(u)/sigma(v)		1.70		

Summary Statistics for TE_c

Range	Observations	Frequency
0.106≤ < 0.268	19	0.0353
0.268≤ < 0.429	67	0.1245
0.429≤ < 0.590	169	0.3141
0.590≤ < 0.751	214	0.3978
0.751≤ <0.912	69	0.1283

Mean	Std.Dev.	Min	Max	N
0.58	0.15	0.11	0.91	538

Table 6-3(2) Initial Estimation of Off-Farm Labor Supply and TE_c

Variables	**Estimate**	**Std. Err.**	**B/St.Er.**	**P-value**
Annual Hours Worked Off-Farm	N=538			
Intercept	-657.57	763.08	-0.86	0.3888
TE_c	1038.79(687.90)[2]	456.43	2.28	0.0229
Male	1548.51	483.16	3.21	0.0014
Age	-21.88(-14.48)	7.74	-2.83	0.0047
Training	25.16(16.66)	13.45	1.87	0.0613
Edu_year	137.64(91.15)	28.61	4.81	0.0000
Num_youngkids	-0.24(-0.16)	108.15	-0.002	0.9982
Nonlaborincome	-0.03(-0.023)	0.04	-0.98	0.3270
Farmland	-29.38(-19.46)	5.18	-5.68	0.0000
Crop_area	-1058.94(-701.24)	186.40	-5.68	0.0000
Noncrop_area	317.51(210.26)	459.17	0.69	0.4893
Livestock_crop	2.00(1.33)	45.27	0.04	0.9647
Debt_asset	293.39(194.29)	420.12	0.70	0.4850
Networth	0.009(0.006)	0.003	3.11	0.0018
Land_transfer	393.21	145.23	2.71	0.0068
Enterprise	38.91	151.51	0.26	0.7973
Buses	3.14(2.08)	2.68	1.17	0.2404
Nonaglabor_total	-512.62(-339.46)	379.00	-1.35	0.1762
Log Likelihood	-3122.40			

[2] marginal effect with scale factor 0.66, from Limdep 8.0

Table 6-4(1) Bootstrap Estimation of Crop Production Technical Efficiency

Variables	Estimate	Std. Err.	B/St.Er.
Lncropincome			
Intercept	4.16	0.44	9.47
LnCultivatedarea	0.61	0.05	11.52
Lncrophours	0.03	0.035	0.91
Lnvariableinputs	0.31	0.04	7.33
Lnmoderntool	0.004	0.02	0.20
Lnfarmtool	0.04	0.08	0.49
High	0.05	0.07	0.69
Low	-0.44	0.13	-3.27
Education	0.018	0.01	1.60
MalefarmerR	-0.026	0.19	-0.13
Average age	0.001	0.003	0.27
Contract	-0.009	0.10	-0.09
Land information	0.26	0.07	3.95
Farmservice	0.24	0.08	3.05

Mean	Std.Dev.	Min	Max
0.56	0.18	0.16	0.91

Table 6-4(2). Bootstrap Estimation of Off-Farm Labor Supply and TE_c

Variables	Estimate	Std. Error	B/St.Er.
Annual Hours Worked Off-Farm			
Intercept	-849.53	1304.91	-0.65
TE_c	1014.47	463.81	2.19
Male	1794.15	1146.99	1.56
Age	-21.63	8.21	-2.63
Training	28.48	19.70	1.45
Edu_year	135.47	30.58	4.43
Num_youngkids	5.04	104.64	0.05
Nonlaborincome	-0.03	0.04	-0.90
Farmland	-29.91	6.15	-4.86
Crop_area	-1099.47	187.36	-5.87
Noncrop_area	67.50	832.15	0.08
Livestock_crop	-2.55	47.79	-0.05
Debt_asset	294.52	474.50	0.62
Networth	0.009	0.004	2.40
Land_transfer	397.72	143.59	2.77
Enterprise	55.78	155.86	0.36
Buses	2.742	2.44	1.12
Nonaglabor_total	-538.95	364.67	-1.48

Table 6-5(1) Initial Estimation of Agricultural Production Technical Efficiency

Variables	**Estimate**	**Std. Error**	**B/St.Er.**	**P-value**
LnAg income N=602				
Intercept	2.54	0.35	7.19	0.0000
LnFarmland	0.33	0.04	7.75	0.0000
LnHours	0.17	0.04	4.57	0.0000
LnInvestment	0.44	0.03	15.82	0.0000
LnFarmtool	0.09	0.07	1.33	0.1831
High	0.04	0.07	0.55	0.5843
Low	-0.18	0.13	-1.40	0.1608
Education	0.002	0.01	0.16	0.8767
MalefarmerR	-0.07	0.18	-0.42	0.6750
Average age	-0.004	0.003	-1.57	0.1168
Contract	0.18	0.07	2.48	0.0132
Land information	0.21	0.05	4.18	0.0000
Famservice	0.37	0.07	5.11	0.0000
Log Likelihood		-516.40		
Sigma-squared(v)		0.2643		
Sigma-squared(u)		0.1692		
Sigma=Sqr[s^2(u)+s^2(v)]		0.6584		
Lambda=sigma(u)/sigma(v)		0.8000		

Summary Statistics for TE

Range	observations	Frequency
0.308≤ <0.429	2	0.0033
0.429≤ <0.551	16	0.0266
0.551≤ <0.672	95	0.1578
0.672≤ <0.794	394	0.6545
0.794≤ <0.915	95	0.1578

Mean	Std.Dev.	Min	Max	N
0.725	0.075	0.308	0.915	602

Table 6-5(2) Initial Estimation of Off-Farm Labor Supply and TE

Variables	**Estimate**	**Std. Error**	**B/St.Er.**	**P-value**
Hours Worked Off-Farm	N=602			
Intercept	657.06	820.15	0.80	0.4230
TE	-706.38(-474.51)	789.57	-0.90	0.3710
Male	1224.25	392.49	3.12	0.0018
Age	-24.05(-16.15)	7.07	-3.40	0.0007
Training	26.76(17.98)	12.56	2.13	0.0332
Edu_year	127.28(85.50)	26.29	4.84	0.0000
Num_youngkids	-16.52(-11.10)	101.64	-0.16	0.8709
Nonlaborincome	-0.027(-0.02)	0.03	-0.82	0.4118
Farmland	-27.72(-18.62)	4.77	-5.81	0.0000
Crop_area	-791.59(-531.75)	139.99	-5.66	0.0000
Noncrop_area	137.21(92.17)	427.23	0.32	0.7481
Livestock_crop	-38.92(-26.14)	39.36	-0.99	0.3228
Debt_asset	-212.81(-142.95)	277.61	-0.77	0.4433
Networth	0.01(0.007)	0.003	3.93	0.0001
Land_transfer	411.06	135.25	3.04	0.0024
Enterprise	63.26	140.90	0.45	0.6535
Buses	1.79(1.20)	2.25	0.80	0.4257
Nonaglabor_total	-170.37(-114.45)	341.73	-0.50	0.6181
Log Likelihood	-3508.734			

Table 6-6 (1) Bootstrap Estimation of Agricultural Production Technical Efficiency

Variables	Estimate	Std. Error	B/St.Er.
Dependent Variable LnAg income			
Intercept	2.54	0.35	7.32
LnFarmland	0.32	0.05	6.20
LnHours	0.16	0.04	3.62
LnInvestment	0.46	0.04	10.77
LnFarmtool	0.11	0.07	1.61
High	0.05	0.07	0.70
Low	-0.16	0.11	-1.50
Education	0.0015	0.008	0.18
MalefarmerR	-0.08	0.16	-0.51
Average age	-0.004	0.003	-1.50
Contract	0.18	0.09	2.04
Land information	0.21	0.05	4.18
Famservice	0.37	0.06	6.11
Sigma=Sqr[s^2(u)+s^2(v)]		0.69	
Lambda=sigma(u)/sigma(v)		1.12	

Summary Statistics for TE

Mean	Std.Dev.	Min	Max	N
0.69	0.09	0.23	0.89	602

Table 6-6 (2) Bootstrap Estimation of Off-Farm Labor Supply and TE

Variables	**Estimate**	**Std. Error**	**B/St.Er.**
Annual Hours Worked Off-Farm			
Intercept	457.93	749.07	0.61
TE	-432.94	565.94	-0.765
Male	1280.60	535.57	2.39
Age	-24.04	6.80	-3.54
Training	28.14	17.06	1.65
Edu_year	126.09	24.16	5.22
Num_youngkids	-13.30	92.22	-0.14
Nonlaborincome	-0.03	0.034	-0.83
Farmland	-28.50	5.01	-5.69
Crop_area	-840.22	157.57	-5.33
Noncrop_area	-35.32	651.90	-0.05
Livestock_crop	-48.99	40.08	-1.22
Debt_asset	-171.66	283.68	-0.61
Networth	0.01	0.003	3.50
Land_transfer	412.23	128.02	3.22
Enterprise	56.35	129.42	0.44
Buses	1.57	1.79	0.88
Nonaglabor_total	-200.74	300.56	-0.67

Table 6-7 Returns to Labor (Yuan per Hour)

	N	Mean	Std.Dev.	Min.	Max.
Marginal Returns of Labor [i]					
Crop Cultivation	538	0.33	0.56	0.003	6.13
Agricultural Production	602	1.13	1.56	0.02	18.57
Average Wage of Off-Farm Employment [ii]					
Operators	264	2.12	1.80	0.12	20

[i] The marginal returns of labor are calculated by multiplying the regression coefficient on labor (the elasticity) by the average value product of labor. All figures are in yuan per hour.
[ii] The wage rate is the average across operators (household head) who engage in off-farm employment. Off-farm income has a large missing value.

Chapter 7

Summary of Results and Conclusions

This dissertation deals with the off-farm labor supply of Chinese agricultural households. The objectives were two fold. The first objective was to investigate the relationship between the farm operators' off-farm labor supply and the household's farming efficiency, and to identify the factors affecting the farm operators' off-farm labor supply.

The agricultural household model is adopted as the basis for theoretical discussion. Based on a simple model, it is shown that if agents face multiple job choices, they will compare options and allocate their labor time to maximize total utility, which implies equalizing marginal returns to labor in alternative jobs and in the consumption of leisure. More time spent in one job generally implies less in others. For farm operators with multiple job holdings, the increasing significance of off-farm work may imply less labor effort being supplied to farm work. The model predicts that off-farm labor supply will be inversely related to farming efficiency. The scope of opportunities for an individual farmer is possibly determined by their stock of talents and expertise. The off-farm labor supply decision can be explained combining human capital theory and the concept of the shadow price of time.

Human capital exhibits prominent positive effects on off-farm labor supply. The off-farm labor supply responds to market signals--better-educated people have better opportunities in the labor market. This indicates the existence of off-farm labor markets in rural China. Nearly twenty years (1978-1994) of economic reform have altered Chinese agricultural households' productive activities. Chinese farmers are having more opportunities to participate in off-farm labor market and are able to "sell" their labor in the labor market. Income from non-labor resources has a negligible effect on off-farm labor supply while net worth shows a positive effect on off-farm labor supply. The results suggest that the substitution effect dominates the income effect for Chinese farmers' labor supply, implying that poverty is still the norm in rural China, though it is changing for the better.

Alternative approaches were used to measure farming efficiency. The study in Chapter 4 defined farming efficiency as the ratio of gross farm income to variable costs, represented by instrumental variables. A simultaneous equations Tobit model was estimated. The study didn't find a significant relationship between Chinese farmers' farming efficiency and their off-farm labor supply. An endogeneity test of farming efficiency and off-farm labor supply is rejected. Chapter 6 derived crop production technical efficiency and agricultural production technical efficiency by estimating the stochastic production frontier model. The crop production technical efficiency is found to be positively related to off-farm labor supply and the agricultural production technical efficiency shows no significant effect on off-farm labor supply.

The results are not in line with theoretical expectations. However, this is no surprise given the situation of Chinese farmers: the existence of surplus labor supply due to enormous labor input in agriculture, restrictions on labor movement and tight capital constraints on household farm investment due to poverty. The marginal returns of labor in different activities were calculated based on the estimated results. The marginal product value of labor in the crop production is 0.33 Yuan per hour. The marginal product value of labor in overall agricultural production is 1.13 Yuan per hour. The average wage rate in the off-farm labor market is 2.12 Yuan per hour. The marginal return to labor in agricultural activities is much lower than that in off-farm employment, suggesting that surplus labors are retained in household agricultural activities, especially in crop production. The land allocation system keeps farmland holdings of each household fixed; the more efficient the households are in crop production, the more labor they could supply to off-farm work. The marginal product value of labor in agricultural production is higher than that in crop production because Chinese government policies have been focused on grain supply for the population. As the most important sustenance for Chinese farmers, crop production has retained huge labor forces while non-crop agricultural production has been neglected until recently. In general, surplus labor supply exists in the household agricultural production, causing its marginal returns of labor smaller than the wage rate of off-farm employment. At the same time, the land allocation system creates labor mobility restrictions. The estimation of the off-farm labor supply shows that the permission of free transfer of land substantially encourages off-farm labor supply. It implies that the current land system retains farmer on land -- farmers are constrained to enter off-farm labor market for fear of losing their land use right.

The land allocation system also exhibits strong effects on farming efficiency. Information about land adjustment positively affects farming efficiency. Uncertainty of land use rights deters investments in land improvements. The land allocation system results in the small sizes of the farms, which are a major constraint on raising farm labor productivity, because it precludes the realization of scale economies, particularly in land extensive industries. Farm efficiency could be promoted by expanding the scale of farm operations. A free market for agricultural land, which allows the consolidation of cultivated land in a smaller number of farms, would solve the structural problems of China's small-scale farms; facilitate the efficient allocation of the scarce resource and increase farming efficiency.

In one word, the absence of a land ownership system holds back rural development. It is producing an agricultural surplus but very low farm incomes and massive underemployment. Further reform is called for to reduce labor mobility restrictions due to policy. More transparent and more flexible policies would greatly reduce transaction costs and enhance the efficiency of farmers' labor allocation. More nonagricultural employment opportunities need to be created. Land markets could only be introduced when adequate nonagricultural job alternatives are created for the farmers. In the case that land privatization is infeasible in the near future, it is necessary to facilitate the transfer of land use right.

Additionally, the Household Registration System hinders migration, which may affect farmers' off-farm labor supply decisions, especially for the area where local off-farm labor markets are not well developed. Since permanent migration is impeded by the policy, it is highly possible that some farmers are willing to settle down for lower returns of labor in agricultural activities so that labor surplus are retained in the agriculture. Once restrictions on labor mobility are removed, the surplus labor forces in the agriculture would move out into higher-paying activities, the marginal returns of the labor remaining will increase until it equals the wage rate of off-farm employment.

The second objective was to investigate the switching nature of the operator's off-farm labor supply depending on the spouse's participation status in off-farm labor markets. The joint utility model was employed to model how the operator and the spouse make their labor supply decisions. The model assumes that the household's allocation of time and goods can be analyzed as a single household-utility function, whose arguments are total consumption and the leisure times of each household member, is maximized jointly by both members subject to a budget constraint in which all earnings are pooled. Assuming the utility function is not additively separable in each member's leisure, marginal utilities are conditional on the leisure and consumption status of the other household member. Likewise, assuming farm labor inputs are not separable, marginal productivities of the operator's on-farm labor depend on the spouse's level of on-farm work and vice versa. Therefore, it is implied that labor supply decisions of the head and the spouse are jointly determined.

An endogenous switching regression model shows that the off-farm labor supply decisions of the operator and the spouse are simultaneously made. The off-farm labor supply behavior of operators with spouses working off-farm exhibits some differences from that of the operators with spouses' not working off-farm. Operators with the spouse not working off-farm on average cultivate a larger area of farmland and crop area, which significantly reduce their off-farm labor supply. Consequently they are likely to offer more off-farm labor if their farmland is freely transferable; and the presence of the village's rural enterprise significantly increases their off-farm labor supply. Operators with spouse working off-farm tend to increases their off-farm labor supply when they have adult children working off-farm and have better transportation availability; and they tend to reduce their off-farm labor supply if they have a larger ratio of high quality cultivated area and a larger ratio of vegetable and fruit area to crop area. The labor supply elasticity with respect to net worth is positive for operators in both regimes, but it has a larger value for the operators with spouse working off-farm. It suggests that households in a better economic situation are more likely to have both the operator and the spouse working off-farm.

The results support that the agricultural household is a more relevant decision unit for resource allocation than is its individual members. The policy implications are that even when changes of relevant policies and changes in the off-farm labor market only touch on certain groups of household members directly (for example, male farmers) in terms of anticipated wage levels, job availability, or economic value of home time, the policy changes would also affect time allocation of their spouses and consequently agricultural resource allocation in general. The information is important for making rural economic development policies by help conforming between different political objectives and various measures.

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