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**Land-Tenure Institutions and Agricultural Productivity in Post-
Reform China**

by

Charles C. Krusekopf

**A dissertation submitted in partial fulfillment of
the requirements for the degree of**

Doctor of Philosophy

University of Washington

1999

Program Authorized to Offer Degree: Department of Economics

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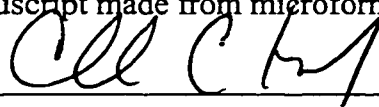
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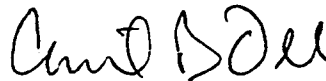
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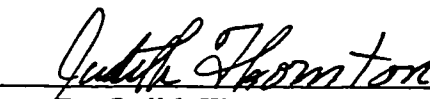
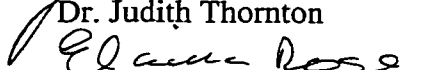
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Abstract

LAND-TENURE INSTITUTIONS AND AGRICULTURAL
PRODUCTIVITY IN POST-REFORM CHINA

by Charles C. Krusekopf

Chairperson of the Supervisory Committee: Professor Anil Deolalikar
Department of Economics

This dissertation seeks to explain and examine the link between land-tenure institutions and agricultural productivity in China. It offers contributions to two bodies of economic literature. The first is the worldwide literature on land-tenure institutions and agricultural productivity. The second is the literature on agricultural development and food security issues in China. The dissertation is divided into four chapters. The first chapter provides an overview of the historical development of the land-tenure system under the HRS. This chapter also introduces several economic arguments with regard to land tenure, and discusses several possible inefficiencies in China's land-tenure system. The second chapter introduces the unique data set that was used in the empirical studies in the dissertation. The data set is one of the only data sets gathered specifically to study the land-tenure system and agricultural productivity in China. The data includes information from corresponding household and village surveys covering 800 households in 83 villages across 4 provinces of China. Analysis of the data reveals that land-tenure rules display a surprising diversity within China. This finding indicates that local village officials play an important role in setting of local land rights in China, despite clear central government pronouncements promoting stronger household land rights.

The third and fourth chapters of the dissertation examine the link between land-tenure institutions and household agricultural production. The chapters adopt a restricted profit-function approach to the study of land tenure institutions. The empirical applications represent the first time that a restricted profit function approach has been applied to the study of certain land-tenure measures, such as land-tenure security and land fragmentation. Both Cobb-Douglas and translog functional forms are estimated, and the results indicate that land-tenure institutions significantly influence agricultural productivity in China. Poor land-tenure security, land fragmentation and small farm size are all shown to reduce household productivity in agriculture.

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Those who have experienced it understand that writing a dissertation is a long journey that enhances self-awareness. During the three years that I worked on this paper, I gained a greater appreciation and understanding of the concept of comparative advantage. Having completed the requirements necessary for this degree, it is now time to move on and utilize mine.

DEDICATION

I would like to dedicate this dissertation to my Dad, who is always there for me, in good times and bad, the center of my life. May we experience many more journeys together.

INTRODUCTION

The development of the Household Responsibility System (HRS) in Chinese agriculture resulted in a rapid rise in agricultural production and farm household income. From 1978 to 1984, the value of agricultural output in China grew by 7.7 percent per year and rural household income increased by 14 percent per year (Lin 1992; Putterman 1993). Several studies have shown that improved institutional structures under the HRS contributed to the rise in agricultural production and rural household income during this time period (Lin 1987a, 1992; McMillan et al 1989; Wen 1989). However, by the mid-1980's Chinese agricultural output stagnated. From 1985 to 1993 total agricultural output rose only 2.5 percent per year, and grain output rose less than 1 percent per year.

A number of researchers have hypothesized that inefficiencies in the land-tenure system under the HRS are responsible for this slow-down in agricultural output (Feder et al 1989; Putterman 1993; Prosterman et al 1994a; Cheng and Tsang 1995; Rozelle et al 1998; Carter and Yao 1998; Turner et al 1998; Li 1998). Citing a body of international studies linking land tenure to agricultural productivity, these researchers have identified poor land-tenure security and poor land allocation mechanisms as likely causes of production inefficiency in Chinese agriculture. Several of these papers take a descriptive, political economy approach to their studies of Chinese agriculture (Prosterman et al 1994a; Cheng and Tsang 1995). Other papers offer empirical studies (Feder et al 1989; Putterman 1993; Rozelle et al 1998; Carter and Yao 1998; Turner et al 1998; Li 1998). With the exception of Li (1998), however, no papers have attempted a comprehensive examination of land-tenure institutions in China.

The goal of this dissertation is to increase the understanding of the link between land-tenure institutions in China and agricultural productivity. By providing a comprehensive view of the agricultural land tenure situation in China, it is hoped that this paper can play a role in the development of more efficient institutions in Chinese agriculture. It draws on and extends the worldwide literature on land tenure and agricultural productivity. It also adds to the literature on agricultural development and food security issues in China.

The paper extends the previous literature on land tenure and agricultural production in several areas. First, it offers one of the first comprehensive looks at the diversity of land rights present in China under the HRS. It develops several unique measures of land tenure rights, and utilizes a unique two-period, cross-section data set to explore how land rights vary across regions and over time. The data set used is one of the most comprehensive data sets gathered in China for the purpose of studying land-tenure institutions and agricultural productivity. Most previous studies use data sets gathered to study agricultural production, not land-tenure issues. Such data sets lack good information on the land-tenure situation of households and villages. The data set used in this work includes information on land-tenure institutions at both a village and household level, as well as information on household agricultural inputs and outputs, household and village characteristics and other important data. The two-period nature of the data set also permits the observation of land-tenure measures over time, an aspect not covered by any previous study.

In addition to the advances permitted through use of the data set, this dissertation offers several unique empirical applications. Most importantly, it offers the first application of the restricted profit-function approach to the study of several key land-tenure institutions such as land-tenure security and land fragmentation. Previous studies of land-tenure and agricultural production rely on direct estimation of

investment and production functions. Such estimates have been shown to be biased and inconsistent. By applying duality theory to the study of land-tenure institutions, this dissertation offers a more robust look at the link between key land-tenure measures and agricultural productivity. The study is also one of the first estimations of a restricted profit function for Chinese agriculture. Many of the results of the estimation, such as the calculation of price and substitution elasticities, represent the first time this information has been presented for post-reform Chinese agriculture.

The dissertation is organized in four chapters that provide an overview and empirical examination of land-tenure institutions in China. Chapter 1 offers a historical overview and description of land-tenure institutions under the Household Responsibility System in China. Chapter 2 introduces the data set and examines variations in land-tenure policies among regional and local areas in China. It shows that despite central government support for a universal land-tenure system in China, significant heterogeneity in land rights exists across the country. Chapter 3 examines the impact that land-tenure institutions have on agricultural production in China. It adopts a Cobb-Douglas restricted profit-function approach to test for relative economic efficiency among households with different land-tenure statuses. The land-tenure identified and studied includes land-tenure security, land fragmentation and farm size.

Chapter 4 reexamines several of the hypotheses from Chapter 3 using a translog functional form. The translog functional form places minimal a priori restrictions on the parameters included in the estimation. One advantage of using the translog form is that it allows estimation of the full set of own- and cross- price and substitution elasticities. This paper offers the first published attempt to calculate these elasticities. Chapters 3 and 4 both find that land-tenure institutions can have a significant impact on agricultural productivity. For example, land readjustments and

land fragmentation are found to reduce the economic efficiency of agricultural production.

Finally, conclusions, extensions and policy recommendations are summarized in the Conclusion to the dissertation. The descriptive and empirical work contained in the dissertation provides important information for understanding agricultural production in China under the Household Responsibility System. The results tend to confirm the findings of other researchers with regard to land-tenure impacts in China, and therefore add additional evidence that the organization of land-tenure institutions must be considered in attempts to improve agricultural productivity in the country. The results indicate that improvements in tenure security and other household land rights should lead to increases in agricultural productivity. Because changes to “the rules of the game” do not require the addition of a large amount of scarce physical resources, the amount of investment necessary to increase production by improving the land-tenure system is relatively low. Therefore, improvements to the land-tenure system provide a promising and relatively inexpensive way for the Chinese government to increase agricultural production.

CHAPTER 1: LAND-TENURE INSTITUTIONS UNDER THE HOUSEHOLD RESPONSIBILITY SYSTEM

SECTION 1.1 INTRODUCTION

Beginning in the late 1970's, one of the first economic reform programs in China after Deng Xiaoping's return to power was a reform of the system of agricultural production in the country. One key aspect of this reform was the break-up of collective forms of agricultural organization and the subsequent transfer of the use rights to almost all the agricultural land in the country to individual households. The household-based production system that developed in China as a result of these reforms is known as the Household Responsibility System (HRS). By the mid-1980's, almost all villages in China had adopted the HRS, and it remains the basic organizational structure for agricultural production in China today.

Much of the literature on the HRS to date has focused on the almost universal shift in Chinese agriculture from a system based on collective production to one based on individual household production¹. Most of these studies provide short histories of how the HRS was developed, descriptions of the general institutional and contract arrangements under the HRS, and discussions and analysis of some problems or inefficiencies thought to exist in the HRS structure. Outside of work by Li (1998), however, few of the studies have focused on the significant variations in policies that exist at a local level under the overall structure of the HRS. Previous studies typically

¹ See for example: Lardy (1983); Wiens (1987); Sicular (1988b); the various papers in Joint Economic Committee (1992); Mai and Timmer (1992); Zhu and Jiang (1993); Putterman (1993); Cheng and Tsang (1995).

ignore the issue of local variations in HRS organization, or assume that local HRS structures are based on national policies adopted by the central government.

This paper focuses on one key aspect of the HRS, namely the institutional framework of the HRS related to land tenure. The institutions examined encompass both local land-tenure policies and the policy makers involved in setting the land-tenure rules. It attempts to extend the existing literature on the Household Responsibility System and agricultural production by systematically examining variations in land-tenure policies among regional and local areas in China. Land-tenure policies that affect land-tenure security, land-transfer rights and land-use rights are a key aspect of the HRS, and have been the focus of central government efforts to strengthen and improve its operation. Heterogeneity in such policies is strong evidence that significant variations exist within the overall HRS framework. Such heterogeneity implies that local and regional conditions and institutions, rather than national rules, shape agricultural policies at the local level. Knowledge of variations in land-tenure institutions will allow for the development of appropriate policies for improving agricultural productivity in China.

This Chapter is organized as follows: Section 1.2 offers an overview of the basic structure of the Household Responsibility System and national policies regarding land-tenure rights; Section 1.3 describes the historical development of the HRS; Section 1.4 discusses problems related to land-tenure rights under the HRS; Section 1.5 discusses the “second stage” of land-tenure reform efforts in China.

SECTION 1.2 BASIC STRUCTURE OF THE HRS

Under the HRS, the use rights to the land of the former agricultural collectives are assigned to individual households. The land itself remains collectively owned, but individual households contract the use rights to several parcels of land in their village

area. Officially, written contracts between the local village authorities and individual households are created. These contracts specify a contract time period and the rights and obligations of both parties to the contract. In practice, however, explicit written contracts are often not created. Field researchers have found that few households can produce written contracts, either because they were never created in the first place or because they have been lost since they were first signed (Prosterman et al 1994a).

The lack of written contracts, however, does not invalidate the understood arrangements under the HRS. Under the HRS, households make most decisions about what crops to plant, what inputs to use and what to do with the crop output - consume it, sell it to the state, or sell it in the private market. In return for the use of village land, households must turn over a portion of their output to village authorities to fulfill grain quotas, meet other requirements such as adhering to family-planning rules, and recognize the authority of the village leaders over land. In essence, the HRS reforms shift the basic unit of production in Chinese agriculture from the collective team to the individual village household, but the HRS does not fully privatize village agricultural land.

Under the HRS, households do not pay a direct rent to the village for the use of village land. However, they do have certain responsibilities they must fulfill to receive a land assignment. For example, households are required to abide by production quotas for grain, provide "voluntary" labor for village projects, meet family planning targets and pay certain taxes and fees. The production quota is set based on the size and fertility of the land the family holds. Households receive a below-market price for the grain they turn in under the quota. While the quota requirements serve as a tax on agricultural households, studies have shown that the combined value of the quota and other land taxes are well below the market-clearing rent for the land (Putterman 1993).

While village leaders no longer have the control over land resources that they enjoyed under the collective system, they retain power over many aspects of land rights under the HRS. Local officials exercise a great deal of control over how land in a village is allocated and reallocated, and also can regulate some aspects of land use and transfer. Some observers have referred to village leaders as “socialist landlords” under the HRS because of their control over village land resources (Oi 1989).

SECTION 1.3 HISTORICAL DEVELOPMENT OF THE HRS

As with many economic reforms in China, the HRS developed through experiments that were initiated at a local rather than a national level. In the era of reform that began after Deng Xiaoping returned to power in late 1978, the central government began to permit some local flexibility with regard to incentive schemes for agricultural workers. Such schemes were permitted as long as they preserved the collective nature of land holding and agricultural production (Cheng and Tsang 1995). However, certain local areas soon went against central government dictates and began contracting agricultural land directly to individual households. This form of management had precedents in certain pre- and post-revolutionary arrangements and in the system of “private plots” that continued through the collective era², but it went directly against central government policies that forbade household-based management systems (Cheng and Tsang 1995).

Although the central government did not approve of the new management form, it also did not actively work to prevent its spread. This was due primarily to the fact that the first areas to adopt household-based contracting systems were poorer

² Even under the collective system, most families were allowed to keep “private plots”, small areas of land that the household directly controlled. Households were allowed to grow any crop they desired on the plots, and most of the produce was consumed within the household. Under the HRS, certain land is labeled as private plots and allocated to each household. Such plots make up approximately 6.2 percent of the national agricultural land (Cheng and Tsang 1995).

areas where the collective system was poorly organized and ineffective (He 1995). The government, however, remained leery of endorsing the new form of management for all farm areas due to ideological concerns and the fear that the break up of the collectives would threaten food security in the country (Carter et al 1996).

The area of most concern for the central government was ensuring the delivery of low-cost grain from the countryside for subsidized distribution to urban workers. The tight government controls and undeveloped markets under the collective system ensured that such grain was reliably delivered from the rural collectives to the cities. The move toward individual producers and decentralized markets under the HRS exposed the central and local governments to risk that the required grain would not be delivered. This risk is one of the main reasons why the central government was reluctant to endorse the HRS (Carter et al 1996). The HRS reforms were allowed to continue, however, in poorer areas where the collective system was not functioning well. In these areas there was less risk of disrupting grain deliveries and greater potential for gains under the HRS (He 1995).

The central government became more accepting of the HRS in the early 1980's as ideological constraints loosened, agricultural output in areas that adopted the HRS soared, and the central government discovered ways to adapt the grain quota system to the new household-based management structures (Cheng and Tsang 1995). The HRS is credited with helping to increase agricultural production in the country. From 1979 to 1981, the output of many crops in China showed double-digit percentage increases annually (Putterman 1993). Some of the increase in production during this time can be attributed to reforms such as price reforms and market development that were not directly related to the HRS. However, the HRS is credited with playing a major role in improving output in the areas where it was adopted (Lin 1987a, 1992; McMillan et al 1989; Wen 1989; Putterman 1993).

One reason for the rapid adoption of the HRS was that central and local governments were able to find ways to integrate the quota-grain system with the HRS. Under the HRS, grain quotas were set by higher-level government officials for geographic areas from the provincial to the village level. At the village level, local officials are responsible for assigning quota levels to each household and ensuring that the overall village quota is fulfilled. There is evidence that village-level officials are able to use their power over land allocation and reallocation to ensure that each household meets its assigned quota (Li 1998; Oi 1989). In practice, almost all households and villages are able to meet their quota deliveries to government authorities (Rozelle 1994).

The success of the HRS in increasing agricultural production and meeting quota requirements led the Chinese central government to officially endorse the HRS in 1982. During that year, the Chinese Communist Party (CCP) issued Central Committee Document No. 1, which stated that contracting agricultural land to households was consistent with socialism. This endorsement paved the way for the rapid adoption of the HRS model across China. At the beginning of 1982, only 22 percent of Chinese villages had adopted the HRS, mostly in poorer, inland areas. By the end of 1982, after the central government endorsed the HRS, over 70 percent of Chinese villages had adopted HRS management practices. By the end of 1983, almost 99 percent of Chinese villages had adopted the HRS, and it remains the agricultural management system for almost all Chinese villages today (Putterman 1993).

SECTION 1.4 LAND-TENURE ISSUES UNDER THE HRS

The initial adoption of the HRS model across China resulted in a rapid rise in agricultural production and farm household income. From 1978 to 1984, the value of agricultural output in China grew by 7.7 percent per year and rural household income

increased by 14 percent per year (Lin 1992; Putterman 1993). Several studies have confirmed that the institutional changes created by the HRS system were the primary cause of the rapid rise in agricultural production and rural household income during this time period (Lin 1987a, 1992; McMillan et al 1989; Wen 1989). The move from collective to individual management of agricultural production improved farmer incentives and eliminated problems of supervision inherent in the collective structure (Putterman 1993).

After an initial period of rapid increase, however, Chinese agricultural output began to stagnate. From 1985 to 1993 total agricultural output rose only 2.5 percent per year, and grain output rose less than 1 percent per year. The Chinese government and other analysts have been examining aspects of the HRS structure in an effort to understand why agricultural production slowed in the late 1980's and early 1990's. One focus of the research has been land-tenure institutions in rural areas. Two issues related to the land-tenure system under the HRS have been identified by researchers as potential factors behind the slowdown in agricultural growth. These include: the perception that the HRS provides inadequate tenure security to farm households; and the idea that the HRS does not do an efficient job of allocating and reallocating rural land (Feder et al 1989; Putterman 1993; Prosterman et al 1994a; Cheng and Tsang 1995; Rozelle et al 1998; Yao and Carter 1996). This section of the paper outlines the major international findings related to land-tenure security issues, and discusses land-tenure security in the Chinese context. The next section describes how the Chinese government has reacted to the perceived problems in land-tenure institutions.

1.4.1 POOR LAND-TENURE SECURITY

The first major criticism of land management in China is that under the HRS, farm households experience poor land-tenure security. Economic research from a variety of countries has shown that poor land-tenure security can have potentially

large negative impacts on agricultural productivity (Blarel 1990; Roth et al 1993; Feder et al 1988; Besley 1995; Carter and Olinto 1996). These studies cite three primary ways in which land tenure affects agricultural productivity. First, households are unwilling to make long-term improvements to land if they do not enjoy secure tenure on the land they farm. Households will not make investments to land if they are unsure whether or not they will hold the land long enough to gain a return on their investment. Over time, the lack of investment and maintenance will lower the productivity of the land (Blarel 1990; Roth et al 1993).

Second, the lack of secure land tenure might prevent households from using their land as collateral in the credit market. The availability of credit relaxes capital constraints and permits increased investment and output. Households without secure land tenure are often shut out of credit markets (Feder et al 1988). Third, more secure land tenure promotes land transfers and permits a better allocation of land among village households. Households without secure land tenure have trouble participating in land markets, and thus areas with insecure land tenure might have poor land allocation (Carter and Olinto 1996). Through these three mechanisms, poor land-tenure security would be expected to create inefficiencies in agriculture and reduce potential output.

Several studies have confirmed that insecure tenure for agricultural land might be a significant problem in China. In a study across several regions of China, Prosterman et al (1994) observed that few rural households made long-term investments in their agricultural land due to concerns about tenure security. Rozelle et al (1996) and Li (1998) found that land-tenure security in China had an important and statistically significant effect on input use and production. Carter and Yao (1998) found that households in China with lower levels of tenure security significantly decreased land-specific agricultural investment and agricultural output.

The poor tenure security observed in China is created by two factors, the length of the HRS land-tenure contracts and administrative land reallocations by village officials during the contract period. Initially most HRS contracts were for a fairly short period of time, typically 3 years or less. This short time period was not long enough to encourage farm households to make long-term investments in their land (Prosterman et al 1994a; Putterman 1993). Since that time, land contract terms have increased, but households in many areas still do not have secure rights to their land due to periodic reallocations of land by village authorities.

Land contracts under the HRS rarely guarantee households the right to specific parcels of land for the full term of the contract. Village leaders often reallocate some or all of the village's agricultural land among village households through administrative means. These reallocations can occur during the middle of a contract period, and sometimes occur even after the village leaders assure households that the village land allocation will not be adjusted. When land is allocated to households through HRS contracts, some villages make stipulations that land might be reallocated during the contract period. Other villages make stipulations that land will not be reallocated for any reason during the contract period. However, in practice the stipulated regulations are not always followed. For example, a 1989 survey of 253 villages in China found that 36 percent of villages reallocated land even after adopting a policy explicitly stating that land in the village would not be reallocated by administrative means (He 1995). Overall, surveys of Chinese villages have shown that over two-thirds of villages in China have reallocated land using administrative measures, often in the midst of land-contract time periods (He 1995; Li 1998). It is clear therefore that the existence of long-term contracts to land is often not a sufficient condition to ensure tenure security for agricultural households because of administrative reallocations of land within the time period of the HRS contracts.

1.4.2 INEFFICIENT LAND REALLOCATION

A second issue raised by the Chinese government and other observers of the HRS is that the system did not efficiently allocate land to households after the break up of the collectives, and has since prevented the development of a system for efficiently reallocating land among households. Village-wide production levels are maximized when the marginal products of land are equalized across the village households. Each household should have an amount of land that matches the size and abilities of its available labor force. Therefore, if land and labor are not well matched, and no mechanism exists to efficiently reallocate land among households, agricultural production for the village as a whole will not be maximized.

Concerns have been raised about four specific issues related to land allocation and reallocation under the HRS. These concerns include: questions about the efficiency of the initial allocation of land after the implementation of the HRS; barriers to land transfer under the HRS; problems of land fragmentation; and the extremely small size of most farms. First, there are concerns that the initial distribution of land after the break-up of the collectives was not efficient. After the break up of the collectives, most agricultural land in China was divided into small parcels and allocated to individual households based on the total population of the household rather than by the number or quality of laborers or other productivity criteria. Because each household has differing demographics, such as age, education, experience and ability, an allocation of land based only on the total number of persons in a household can lead to inefficiencies due to differing marginal products of labor between households (Lin 1987a, 1995).

Second, because the HRS did not initially allow for market transactions between households, and because such transactions continue to be rare, land allocations might become less efficient over time as household demographics change

through marriages, births, deaths, and work opportunities outside agriculture. Households that lose workers through death, marriage or jobs outside of agriculture might have “too much” land for their available labor force, while households that gain workers through birth or marriage might have “too little” land. If village households were allowed to freely transfer their assigned land to other households through market-based rental or entrustment transactions, then a more efficient allocation of land would be expected to result³.

A third problem with the land allocation in China that is often cited is related to the fragmented nature of most household land holdings in China. When land was initially allocated from the collectives to households under the HRS each family received a number of small plots of land rather than one large, contiguous piece. This was to ensure that land of differing qualities was fairly distributed among village households. However, land holdings in China are now extremely fragmented. For example, a 1986 survey found that the average household in China held 9.2 mu of land (0.61 hectare) in 9 different plots scattered around the village (Huang 1995). Plot sizes are generally less than 0.1 hectare each. Fragmentation is thought to reduce production efficiency due to the time farm households must spend traveling between their scattered parcels, as well as inefficiencies in the use of certain inputs such as farm machinery. Several studies have shown that land fragmentation may reduce agricultural productivity in China (Brandt 1987; Fleischer and Liu 1992).

A fourth problem in land allocation under the HRS is the problem of the extremely small size of total land holdings by Chinese farmers. In addition to being fragmented, overall holdings of land in China are among the smallest in the world.

³ A rental transaction involves a cash or in-kind payment in compensation for the transfer of use rights between the two parties involved in the transaction. An entrustment is usually an agreement between a household and close relatives or friends to transfer use rights temporarily without direct compensation. In both cases the person receiving the land is usually responsible for meeting the agricultural quotas and taxes on the transacted land.

Scale economies may be present due to the lumpy nature of farm inputs, such as machinery or agricultural skills, which can only be utilized on farms above a minimum size. Empirically, a few studies have found weak evidence of scale economy effects in China (Feder et al 1992; Fleischer and Liu 1992; Cheng and Tsang 1995; Huang 1995).

Given the identified inefficiencies in the structure of land allocation under the HRS, the Chinese central government has encouraged the development of land markets as the primary means of facilitating land reallocation (Zhang and Makeham 1992; Cheng and Tsang 1995). With functioning land markets, more productive farmers can rent land from less productive farmers. Land markets might also provide a solution to possible problems from land fragmentation and scale inefficiencies by allowing households to consolidate land holdings through market transactions. A well-functioning land market would facilitate an efficient allocation of land in the village by allowing land holdings to adjust to both initial inefficiencies and continuing demographic changes.

It should be noted that the problems of land allocation can be addressed through both administrative means and market methods. Under the administrative method, a central administrator attempts to reallocate land among households to achieve the socially optimal allocation. However, a body of economic literature indicates that such centralized schemes work less efficiently than decentralized market based approaches because of information problems (De Alessi 1980). For example, it is generally accepted that central administrators have less information than individual households on the labor and other resources those households have available for agricultural production. Individual households would be better positioned than administrators to make decisions about the optimal allocation of their resources, including how much land to contract. Therefore, market-based approaches are

generally felt to more efficient at allocating resources than centralized administrative structures.

In summary, researchers have cited several ways in which land-tenure insecurity and inefficiencies in land allocation and reallocation reduce the productivity of agricultural land. Several observers have identified these land tenure issues as important reasons that Chinese agricultural yields stagnated in the late 1980's and early 1990's. In response to perceived problems related to land-tenure administration under the HRS, the Chinese government issued a series of policy directives supporting secure household land rights. The next section of this paper outlines a number of policy statements made by the Chinese government with regard to land tenure under the HRS.

SECTION 1.5 THE "SECOND-STAGE" LAND REFORM IN CHINA

Despite its initial reluctance to endorse the HRS, the central government has continued to support it despite the slowdown in agricultural growth and perceived problems in some aspects of the system. The central government has focused on ways to improve the operation of the HRS, rather than endorsing a return to the collective structures or some other management system. The continued reforms in the agricultural system are often referred to as "second-stage" HRS reforms because they involve a refinement of the HRS that was initially adopted. A primary focus of these second-stage reforms has been central government efforts to improve the system of land-tenure rights and land management in the country.

For example, the Chinese central government has consistently supported the development of more individualized land-tenure rights under the HRS. While not supporting fully privatized land rights, central government policy has attempted to significantly strengthen household land-tenure security by endorsing efforts to

lengthen the contract term for agricultural land. In 1984 the government issued Rural Work Document #1. This document encouraged local officials to, "...prolong the time period of the contracted land to encourage the peasants to increase their investment to foster the fertility of the soil and practice intensive operation. In general, the time period of the contracted land should be more than 15 years." (Translation from Prosterman et al 1994a). Rural Work Document #1 also included a statement that any readjustments that occur should be minor and should take place only after the expiration of the old contracts and before new contracts are signed. It stressed that any adjustments in land holdings within the contract period should occur through a land market and not through administrative means (Cheng and Tsang 1993). A 1987 CCP document stressed that land under contract should not be adjusted and households should be able to re-contract the same parcels of land as long as the household met the contract requirements (Cheng and Tsang 1993).

In recent years, the Chinese government has again put itself at the forefront of efforts to extend contract periods and prevent the administrative reallocation of land within the contract period. For example, in 1994 the Chinese Central Committee adopted a resolution calling for land-use contracts to be extended another 30 years after their original 15 year right period ended (Prosterman et al 1994a). This resolution also promoted a policy of not reallocating land in response to demographic changes among village households for the full time of the contract period (Cheng and Tsang 1995). For most households, a 30-year use right with no threat of premature reallocation would offer tenure security comparable to full ownership.

With regard to the issue of land allocation and reallocation, the Chinese central government has consistently supported the development and use of market mechanisms, rather than administrative methods, for the transfer of land between households. Evidence of this support can be seen in the numerous policy statements it

has issued reaffirming the rights of peasants to transfer land and encouraging the development of rural land markets. For example, Rural Work Document #1 in 1984 encouraged farmers to transfer land-use rights among themselves, and stressed that decentralized land markets rather than administrative methods are the appropriate method for transferring land among rural households (Cheng and Tsang 1995). In 1985, the central government explicitly authorized the right of farmers to collect compensation for their transfer of use rights.

A 1987 central government endorsed policy document entitled “Deepening Rural Reforms” outlined several ways in which village leaders could facilitate the development of land markets, such as including land quality indicators in land contracts and encouraging compensation for any land improvements when transfers are made (Cheng and Tsang 1995). Several more recent policy statements and central government announcements have reiterated the central government’s support for the development and use of land markets as the primary method of land allocation in rural areas (Zhang and Makeham 1992; Cheng and Tsang 1995).

In a little over a decade from the time it first endorsed the HRS the Chinese central government has become one of the strongest proponents of household rights in agricultural production. It has supported 30-year use rights with no mid-contract reallocations, and the right of households to freely transfer land through a rental market. However, despite the numerous policy statements and clear views of the central government, surveys have indicated that a wide disparity of land-tenure rights continue to exist within China (He 1995; Li 1998). This disparity in land-tenure rights across the country offers evidence that central government policies are not the primary determinant of land-tenure rights in China.

SECTION 1.6 CONCLUSION

This chapter of the dissertation reviews the development of the HRS in Chinese agriculture and the basic framework of land rights under the HRS in China. It briefly describes the history of the HRS, and highlights several areas of concern with regard to land administration under the HRS. It outlines the central government's policies with regard to land management and describes how these policies have responded to perceived problems of land-tenure insecurity and poor land allocation and reallocation. The central government policies have generally sought to improve land-tenure security and other land rights for individual households. However, as is shown in the next chapter of this dissertation, such central government policies on land rights are not always followed at a local level. The next chapter of this dissertation introduces and utilizes a unique two-period data set to examine the land tenure situation for villages and households across a range of geographical and socioeconomic areas in China. It describes the study areas and data gathered, and provides a number of summary statistics to show how land rights vary across the study areas.

CHAPTER 2: EVIDENCE OF LAND-TENURE HETEROGENEITY IN CHINA

SECTION 2.1 INTRODUCTION

Given the almost universal adoption of the HRS form of agricultural management within China and the clear policy statements offered by the central government regarding key aspects of land tenure administration in the country, it might be expected that land-tenure institutions would be fairly homogenous across the country. However, as with many economic reforms in China, pronouncements from the central government have not necessarily translated into unified policies at the local level. For example, in some areas households enjoy secure rights to the land they farm, while in other areas land has been administratively reallocated numerous times leading to tenure insecurity. Similar differences exist with regard to land transfer rights among households.

In order to gain a clearer understanding of the diversity of land-tenure rights in China, this chapter of the dissertation utilizes a unique data set that offers a two-period cross-section of observations measuring land rights in the country. The results provide clear evidence that substantial heterogeneity exists with regard to land-tenure institutions in China, even after the almost universal adoption of the HRS. The findings indicate that local government officials have a great deal of influence in determining local land-tenure regulations. The chapter concludes by discussing the implications of these findings for land policy formation in China.

SECTION 2.2 DATA DESCRIPTION

The data set used in this paper was gathered in 83 villages and 800 households in 8 counties across four provinces in China⁴. The surveys were designed by the Development Research Center (DRC) of the State Council of China, with assistance from the Land Tenure Center of the University of Wisconsin. The survey data was collected in 1989 and 1994, and focused on conditions in 1988 and 1993. The surveys included corresponding village and household surveys from 32 villages from Gongzhuling and Dehui counties in Jilin province, 10 villages in Weihui county in Henan province, 30 villages in Shaoxing, Ning and Leqing counties in Zhejiang province, and 11 villages in Anfu and Nancheng counties in Jiangxi province. 100 households in each county were surveyed. The counties included were chosen from a national statistical sample to represent the wide variety of development stages and agricultural zones within China. The villages and households were chosen randomly within the selected counties.

The surveys for 1989 and 1994 were conducted in the same villages and households, and included many of the same households in each time period. Households were interviewed by a representative of the State Statistical Bureau and asked to complete an extensive questionnaire covering household demographics, finances, agricultural production and land holdings and tenure arrangements. The corresponding village survey interviewed village officials in 1994 in all 83 villages and contains information on village attributes in 1988 and 1993. Information gathered included village demographics, village land-use and land-tenure policies, information on agricultural quotas and taxes, and data on village agricultural and non-agricultural

⁴ Political administrative levels in China include, in descending order, province, county, township and village. Each of the larger administrative areas includes several of the smaller areas, for example, each township includes several village areas, and each county includes several townships.

production. Supplemental village survey work was conducted in 1997 to gain additional information not included in the original surveys.

One feature of this data set that distinguishes it from those used in earlier studies is that it includes information on land rights in the surveyed villages across time. Most information in the surveys is available for two years, 1988 and 1993, while some household and village information is available for each year from the introduction of the HRS to 1993. The information in the data set allows an examination of how land reallocation behavior in villages has changed over time in response to land policies and other factors.

The data set is also unique in the amount of information available from its surveys of household and village land rights. For example, the survey indicates the number, timing and size of every village land reallocation from the adoption of the HRS through 1993. This information permits the construction of several measures of land-tenure security. With regard to land transfer and use rights, the household surveys record household perceptions regarding their freedom to freely rent their contracted land to other households, to freely choose which crops to plant, and to choose where to sell the crop output. The information available from the surveys provides a clearer picture of the full set of land rights and land policies in Chinese villages, and how these land rights and land policies have changed over time.

Tables 2.1 and 2.2 offer an overview of some basic characteristics of the households and counties included in the survey. As can be seen in the tables, significant variations in terms of income, land endowment and other factors exist between the different regions of China covered. For example, households in Zhejiang, one of the rapidly growing coastal provinces in south central China, are relatively prosperous and less reliant on agriculture as a source of income than other regions. In

these areas the total amount of land per capita is relatively low, but the land is of high quality judging by agricultural yields. Most farmers in this area grow two rice crops per year. Rice is also the primary crop on the farms in Jiangxi province, which is located in southern China. However off-farm income in this area is much lower than in Zhejiang.

In terms of land resources, the northern province of Jilin is relatively abundant in the amount of land available per capita. However, this land is less productive in terms of agricultural yields than land in other areas. The primary crop in this region is corn. Farmers in Weihui County in central China's Henan province grow both wheat and rice. However, it is the poorest county in the survey with limited off-farm opportunities and low grain yields. Overall, the areas represented in the sample provide a cross-section of the diversity found in demographic and agro-climatic areas across China.

SECTION 2.3 EVIDENCE OF LAND-TENURE HETEROGENEITY

Just as demographic characteristics vary across the areas surveyed, land-tenure administration also shows significant within the sample. While there are many potential aspects of land tenure administration that can be evaluated, this section will focus on descriptions of three of the most important aspects of rural land rights in China: land-tenure security; land-transfer rights; and land use rights. A variety of different methods of measuring each aspect of land rights are available. This paper identifies several methods of quantifying each rights category, and presents alternative measurements for each rights group from the data.

2.3.1 *LAND-TENURE SECURITY*

Several indices related to land-tenure security in China have been considered in previous studies. Almost all of them measure the number and scope of administrative land reallocations in a village. Most authors consider these reallocations to be the primary determinant of the degree of land-tenure security enjoyed by rural households⁵ (Liu et al 1996; Rozelle et al 1998; Turner et al 1998; Carter and Yao 1998; Li 1998). Villages that have reallocated land would be expected to have poorer tenure security than those that have not, and likewise, villages that have reallocated land more frequently or more thoroughly would also be expected to have poorer tenure security.

Administrative land reallocations can be measured in several ways, including a dichotomous variable indicating whether or not a village has reallocated land since the introduction of the HRS or measures of the frequency or size of land reallocation activity in a village. While each of these measures is related, they do yield somewhat distinct information and help build a more complete picture of land reallocation behavior in Chinese villages. For example, some villages reallocate infrequently, but

⁵ Some critics have challenged the notion that variables measuring reallocation behavior or length of tenure accurately reflect the tenure security enjoyed by households. For example, James Kung has argued that in some areas tenure may grow more insecure the longer households hold land. This is because in areas with few past adjustments, households perceive that future adjustments are more likely (Kung 1995). However, this problem might be expected to diminish over time. By 1993 many households had been farming the same land plots for over twelve years, and their villages had never reallocated land. It could plausibly be argued that village leaders in those areas had the time and opportunity to reallocate land, but chose not to do so. It is therefore probably less likely, rather than more likely, that those villages will reallocate their land in the future.

Another argument that has been raised is that areas without reallocations might still have poor tenure security because it may be the case that in these areas village leaders have threatened to reallocate land, even if they did not carry through with the threat. Such threats might induce land-tenure insecurity. However, as Li Guo has described, it might be presumed that village leaders would have to reallocate land at least once to make such a threat credible. Therefore village reallocation behavior would remain a valid instrument for determining land-tenure security (Li 1998). As with all

reallocate all the village land when they do reallocate. (This is known as a large land reallocation.) Other villages reallocate land frequently, but only reallocate part of each household's land or only include a few households in the reallocation. (This is known as a small land reallocation.)

This study introduces two additional measures of land-tenure security that have not been reported in previous published studies. These measures include the average length of time village households have farmed the plots of land in their possession, and the percentage of village households that report having some of their land reallocated. The length of time households have farmed their land reflects both the timing and scope of administrative land reallocations in the village. Farmers in villages without any major land reallocations would have held their land for long periods of time, and be presumed to have relatively secure tenure rights⁶. Likewise, the portion of households reporting having had some of their land reallocated since the introduction of the HRS also indicates the scope of land reallocations in the village. These measures are important because they indicate the actual pattern of land reallocation experienced by households. Previous studies relied only on reported allocation behavior by village leaders. This study allows one to corroborate the village surveys with household survey work.

subjective economic variables, an exact measurement of land-tenure security is impossible. The researcher is forced to do the best that he can with the data and information available to him.

⁶ The number of years the land has been held will vary somewhat from village to village depending on when the HRS was implemented. Therefore, households in a village that have held their land for 13 years versus households in another village that have held their land for only 11 years would not necessarily have poorer land-tenure rights. The change in length of time held between the two villages may only be due to differences in when the HRS was initially implemented. The important thing to consider is the difference between the average length of land holding and the time since the HRS was implemented. Greater disparities indicate land reallocations in that village have been more frequent or more widespread.

Table 2.3 summarizes information on several measures of land-tenure security for households and villages in the eight counties included in the survey. The results indicate that land administration and land-tenure rights vary a great deal both across and within the counties included in the survey. For example, while 65 percent of the villages in the total sample had reallocated land through administrative means at least once since the introduction of the HRS (and 26.5 percent of all villages had reallocated more than once), significant variations in reallocation behavior existed between the counties. In one county, Gongzhuling, only one village had reallocated land, while in two other counties, Dehui and Weihui, all the villages reallocated land. An indication that land reallocation behavior is not tied to regional factors can be seen in the fact that Gongzhuling and Dehui, counties at opposite ends of the reallocation behavior spectrum, are both located in Jilin province in northern China.

It can be noted as well that the frequency of land reallocation differed not only among counties, but also within the villages of a single county. For example, in Anfu County in Jiangxi one village had never reallocated land while another village in the same county had reallocated land six times from 1984-93. Other counties showed less extreme differences in reallocation behavior among villages, but only one county, Dehui, experienced homogeneity in reallocation behavior among the villages in the county. In that county all the villages reallocated one time.

The size of land reallocations also differed greatly between various provincial and county areas. In several counties, such as Weihui and Nancheng, villages primarily carried out large reallocations that reallocated all village land. Other counties, however, reported no large land reallocations. In some cases this was due to an overall low number of land reallocations, while in others the villages reported large numbers of small land reallocations. It might be noted that only two of the 22 villages in the survey that reported reallocating land more than once undertook both large and

small land reallocations. In general, villages chose only one of these two methods to reallocate land.

The two household-level indicators that are unique to this study, the average number of years a household has farmed its land plots and the percent of households reporting reallocation of some portion of their land, are also summarized in Table 2.2. These measures provide additional information that allows a clearer picture of the impacts of the reallocation behavior described in the village surveys. For example, households in villages that report large land reallocations, such as the majority of those in Weihui and Nancheng counties, report relatively short land usage patterns. In these areas, a large majority of households have had their land reallocated.

The pattern is different among households in areas with small land reallocations, such as the villages in Ning and Anfu counties. In these counties, even though the total number of land reallocations is relatively high, only a small portion of village households are affected and most households have continued to farm the same plots of land since land was initially allocated under the HRS. These figures indicate that large and small land reallocations have different impacts in terms of the number of village households and amount of land impacted.

Overall, the results found by the current survey are similar to those found by Li Guo in his 1996 survey of 184 villages across 6 provinces in China and by the Chinese Development Research Center (DRC) in a 280 village survey conducted in 1989. For example, with regard to land readjustments, the Li Guo survey indicated that by 1996 over 90 percent of villages in provinces such as Hubei and Shaanxi had administratively reallocated land, while in other provinces such as Sichuan and Yunnan less than one-third of villages had reallocated land. One consistent result

found in all the surveys is that by the mid 1990's, approximately two-thirds of villages across China had reallocated land administratively.

One interesting finding from the DRC survey is that despite central government policies to the contrary, approximately half the village leaders in the survey indicated that their village had a policy of periodically reallocating land among village households. Only 20 percent of villages had policies never to reallocate land, while the remaining villages had no set policy. However, the survey also found that such policies are not always reliable indicators of actual land administration. Over one-third of the villages that specified that they would never reallocate land had in fact administratively reallocated land (He 1995). This finding indicates the importance of using tenure-security measures based on actual land administration behavior rather than just relying on stated policies, whether local or national.

One issue that has not been described in any previous surveys is the pattern of land reallocations over time and across regions. One would expect that if central government policies have been significant in shaping land-tenure rules at local levels, land reallocation behavior would decline over time as villages abided by the 15-year fixed land contract policies supported by the central government. However, as Table 2.4 indicates, land reallocations have been fairly steady over time⁷. No clear pattern of a reduction in land reallocations emerges. It is clear that villages have continued to reallocate land using both large and small reallocations despite clear central government policies aimed at ending such reallocations.

⁷ No reallocations were reported prior to 1984 (most villages in the survey adopted the HRS from 1981-83), and no data is available beyond 1993.

2.3.2 *LAND-TRANSFER RIGHTS*

A second key aspect of land administration in China involves the rights of households to freely transfer the land they contract to other village households through land-rental markets. As was discussed earlier, such transfers facilitate an efficient allocation of land within the village as more efficient households gain land from less efficient households. Inefficient allocations might arise because of changes in demographics or when household members quit farming to work outside agriculture. Land markets might also reduce any inefficiencies that result from land fragmentation problems or increasing returns to scale

The Chinese central government has strongly supported the rights of households to transfer land under the HRS. However, as is the case with land reallocation policy, local rules on land transfer differ widely across villages. As with land-tenure security, there are several ways to measure land-transfer rights in a village. Most previous studies have used village-level indicators of land-transfer rights (Liu et al 1996; Yao and Carter 1996; Li 1998). Village level indicators rely on survey questions asking village leaders whether land transfers by households are freely allowed, regulated or prohibited in the village. Regulations include provisions that all land transactions be approved by the village council, or involve other restrictions. While such regulations do not necessarily prevent land transactions from taking place, they do raise transaction costs, and would therefore be expected to reduce the total number of transactions conducted.

An alternative measure of land-transfer rights that has been rarely reported due to insufficient data utilizes information provided directly by households on their ability to freely transfer land. In gathering the data to construct this measure, households are directly asked whether they have the right to freely transfer their land. Household-level measures might be a better indicator of transfer rights because the

rights level reported by village leaders might not conform to the rights households feel they have over their land. A household's perception of its land-transfer rights is what ultimately matters when households decide whether or not to enter a land market.

Table 2.5 reports both village- and household-based measures of land-transfer rights. The village-level indicators are taken from a question on the village questionnaire asking village leaders whether farmers are allowed to rent out their land. A village reporting free rights is one that only requires that the state grain quota be fulfilled when land is rented (but no other special approvals are required), or that has no stipulations on land rental. Villages that regulate land transactions generally allow transactions, but require them to be approved by the village council or place restrictions on the type or amount of land that can be transferred. Only a few villages report that land transfers are not permitted. It is interesting to note that the number of villages reporting regulating or preventing land-transfer rights rose slightly from 1988 to 1993, despite central government appeals encouraging the development of land markets.

The land-transfer rights reported by households vary a great deal both across and within different counties. For example, only about one-third of households in two counties, Shaoxing and Weihui, reported in both time periods that they held the right to freely transfer land in both time periods. All the households in two other two counties, Dehui and Anfu, reported the right to transfer land. Significant variations also existed across counties within a single province. Households in the relatively prosperous coastal counties in Zhejiang all reported different levels of land-transfer rights, with higher proportions of households reporting free transfer rights in Ning and Leqing counties, but few households reporting such rights in Shaoxing county.

Other surveys have found similar levels of land-transfer rights in China. For example, the DRC survey of 280 villages found that 72.1 percent of villages permitted land transfers as long as grain quotas and tax obligations were met, while 27.9 percent of villages had regulations prohibiting or tightly regulating such transfers. The survey found that land-transfer rights varied between provinces, from a high of 96 percent of households having freedom to rent their land in Zhejiang province to only 52 percent having the same rights in Shandong province.

Despite the findings of this survey and others that a majority of villages and households in China report having the right to transfer land, the actual number of transfers in most areas of China is small. For example, the DRC village survey estimated that until 1990 less than one percent of farm households had transferred land, and the land involved included only 0.44 percent of cultivated land in the country (Huang 1995). Later surveys have found wider participation in land markets; for example the Li Guo survey found that 79 percent of the surveyed villages had recorded land transactions up to 1995, while in 1988 only 26 percent of villages had land transactions (Li 1998). The same survey found that across China approximately seven percent of households engaged in rental transactions in 1995, up from 1.5 percent in 1988. However, the total portion of village land rented remained under three percent of the total available village land.

The survey utilized for this paper relies on information provided by households on their land transfers over the period 1987 to 1993. Land market activity includes transactions by households obtaining additional land or temporarily reducing the land they cultivate through rental or entrustment arrangements with other households or the village. Most land market transactions are for a period of only one season or year and are conducted with a friend, family member or other village household, with few arrangements involving parties not living in the same village. Village governments

sometimes rent out parcels of village land that have not been allocated to village households or serve as middle persons in the transaction helping families find partners for land transactions. These transactions are different from the land-allocation activities because all parties recognize that the arrangements are only short-term and the long-term use rights to any land that has been transacted through a market remains with the household that contracted the land or the village⁸.

Table 2.4 indicates that land transfers increased significantly over the time period of the survey. Almost no land transfers are recorded in the early years of the survey, while significant activity is recorded in later years. Land transfer activity varies widely between local areas. Table 2.5 provides information on the geographic distribution of land transfer activity. As indicated in Table 2.5, land market activity is fairly widespread, but generally quite thin. Overall, almost two-thirds of villages in China report some land market activity. However, the frequency of land market transfers is quite low in most areas. For example, in 1993, only one county had more than ten percent of its households participating in land markets. In Jilin and Jinagxi provinces, large numbers of villages report land transfers, but most only record a few transfers per year. Other surveys have also found that land market activity can vary widely, with a majority of households in some areas participating in land markets, while few households participate in other areas (Lin 1995).

It might be noted that the number of land transfers is only weakly correlated with the degree of transfer rights reported by households. For example, Ning County in Zhejiang reports a relatively high number of households participating in land

⁸ Many villages set aside small portions of the overall village land that is not officially allocated to particular households under the HRS. This land is known as "standby land". The stated reason for setting it aside is to allow village officials to allocate portions of it over time to village households that increase their population. Until it is allocated, most villages rent the land to households through

transfers, but a relatively low number of households reporting the right to freely transfer land. Other counties, however, such as Shaoxing in Zhejiang, report few land transfers and substantial restrictions on transfers. In these areas the transfer restrictions may be preventing land markets from operating effectively. Other studies found similar mixed results between land-transfer rights and the actual level of land transfers in the market (Li 1998).

Such findings are not surprising given that land-transfer rights are only one of several factors influencing land transfers. As outlined by Zimmerman and Carter (1996), for transactions to occur participants in the market must hold differing views on the value of the item in question. If the parties are relatively homogenous then few market transactions will occur. In the case of land, the returns to the party renting in land must be higher than the returns expected by the party renting out land for a transaction to occur. Land-transfer rights play a role in activating land transfers in that such rights are a measure of transactions costs in land markets. Restrictions on land transfers will raise the cost of a potential transfer. Increased transactions costs will reduce the number of transfers because fewer transfers will now be profitable for both parties. The differences in the valuation placed on the item to be traded must be larger when transaction costs are high. If the differences in valuation are small, then few transactions will take place. Several studies have confirmed that land transfers are reduced from their potential levels due to the presence of transaction costs (Skoufias 1995; Zimmerman and Carter 1996). Transactions might still occur in areas with greater land transfer regulations, but households must hold larger differences in the value of the object in question.

short-term agreements. Households, therefore, will report land received in this manner as “land rented in” in the survey.

One explanation for why Zhejiang experiences relatively large numbers of land transactions even though land-transfer rights are not generally higher than in other areas might be related to the availability of outside work opportunities in Zhejiang. Households with members that work outside agriculture would likely place a lower value on agricultural land than households who work only in agriculture, thereby creating the conditions necessary for a profitable exchange. Such exchanges might still occur even if land-transfer rights are somewhat restricted, as the benefits of the transaction outweigh any additional costs the regulations impose. If transfer restrictions are too high, however, as may be the case in Shaoxing County, potentially profitable transfers may not occur. In areas with more homogenous populations, regulations on land transactions might impose greater constraints on the number of transactions.

2.3.3 LAND-USE RIGHTS

In addition to land-transfer rights and land-tenure security, the current survey also includes several additional measures of the use rights that households enjoy on their parcels of land. These measures provide additional information on the bundle of land rights held by households in rural China. Table 2.6 offers a summary of four such measures, including the right to freely plant crops, the right to freely sell products from the land, the right to use land as collateral, and the right to inherit land-use rights.

Most households in China report having the right to freely plant crops on their land and freely sell the output from their land. These questions measure the influence and control of village leaders over land use and crop sales decisions by households. The crops in question are not the crops covered under the quota system, but rather the crops and output produced by households outside the quota system. Even after land

was allocated to households under HRS contracts, village leaders in some areas control the crops planted by households, the use of inputs such as fertilizers, and the sales of crops by village households. Such restrictions were much more common in the early stages of the HRS, and as shown in Table 2.6 are generally being reduced in most areas.

Two additional measures of land rights that are covered in the survey include the right of village households to use land as collateral and the right to inherit land-use rights by passing HRS contracts among generations. The right to inherit use rights is held by approximately half of all rural households, but such rights vary a great deal across the survey. For example, in Zhejiang almost all households in Leqing County can pass HRS contracts from one generation to the next, but almost no households in Shaoxing have such rights. The right to use land as collateral is restricted in almost all areas of the country. Several studies in other countries have indicated that secure land-tenure rights can assist families in borrowing funds to make investments in land and other projects (Feder et al 1988). However, in China few farm households borrow funds due to the lack of private capital markets and a scarcity of government rural credit schemes. Therefore land tenure's impact on current household borrowing should not be large, although in the future the use of land as collateral might become more feasible as credit markets develop, especially in areas where land rights are strengthened.

In conclusion, it might be noted from the information in Tables 2.3, 2.4 and 2.6 that various measures of land rights are correlated within one village. Evidence of this fact can be seen in that certain counties, such as Leqing and Ning in Zhejiang and Dehui in Jilin and Anfu in Jiangxi, consistently report high levels of land rights across all measures of land-tenure security, land-transfer rights and land-use rights. In other counties, such as Shaoxing in Zhejiang and Weihui in Henan, low levels of land rights

are reported across all measures. These findings indicate that villages are often more or less restrictive across the whole bundle of land rights, and do not generally provide one right without also providing the others. Villages differ in whether they rely on more centralized schemes of management or less centralized schemes, but few villages provide centralized control over one right while allowing decentralized mechanisms to work for another.

SECTION 2.4 VILLAGE OFFICIALS AND LAND-TENURE RIGHTS

Despite the fact that the Chinese central government has consistently supported improved land-tenure security and land-transfer rights for agricultural households in its policy statements, it is clear from the current survey and other surveys conducted in China that land rights vary significantly from county to county and even from village to village. While some aspects of land rights have strengthened over time and some areas have followed central directives with regard to land policies, significant heterogeneity in land rights continues to exist. In most areas of the country the level of property rights to land held by households, especially tenure-security rights, continue to remain below those called for by central government directives. These findings provide evidence that, while central government policies may play a role in determining the scope of property rights to land, they are not the final determinant of local land rules in China.

The fact that land-tenure rules vary not only by province or county, but also at a local village level, provides evidence that property rights to land in China are primarily determined at the village level. While other parties, namely the central government and local households, also play a role in the formation of property rights for agricultural land, village government officials, also known as cadres, have a great deal of power to set local land regulations and policies. The central role that village

officials in China play in determining local land regulations has been highlighted in several papers and surveys (Oi 1989; Rozelle 1991; Carter et al 1996; Turner et al 1998; Li 1998).

Several hypotheses about village leader decision making with regard to local land rules have been put forth. For example, Turner et al (1998) considers four hypotheses about village land reallocation behavior. First it considers whether land reallocations take place based on simple demographic rules. Second, the paper explores whether reallocations are used to take land from households that do not meet tax obligations. Third, the paper looks at whether reallocations redistribute land rents to favored groups. And finally, it examines whether reallocations take place to move land to higher valued uses. The paper uses a data set that includes information from 215 villages across China. It looks at characteristics of villages that reallocated land, and attempts to match these characteristics to the hypotheses presented. The findings of the paper suggest that the hypothesis that village leaders attempt to move land to higher valued uses has the greatest explanatory power. It finds some evidence, however, that the other hypotheses have some explanatory power.

Li (1998) provides three fundamental motivations for village leader behavior with regard to decisions about village land rights. First, village leaders are concerned about losing their jobs and therefore are motivated by interest protection in developing land rules. Second, village leaders use land rules in an attempt to minimize the cost of achieving required tasks. And third, village leaders develop land rules in an attempt to pursue or maintain equity and efficiency in the village. The paper uses a data set from 184 villages in northern China to empirically test its hypotheses. It finds some support for all three hypotheses in its regression analysis. Overall, the results of previous studies have failed to discover a clear motivation of village leaders with regard to the setting of land-tenure rights, but the crucial role of local officials in setting local land

rights can not be overlooked when considering policy alternatives for improving land rights.

SECTION 2.5 CONCLUSIONS

This chapter of the dissertation introduces a unique, two-period data set to examine the various measures of land rights held by households in rural areas of China. Examination of the data reveals that significant heterogeneity exists in land-tenure rules across the country. Most rural areas do not conform to central government policies with regard to land-tenure security and land-transfer rights. However, land-tenure rights vary a great deal across the country. Rights are shown to differ from village to village within one county or township area. This analysis makes it clear that central government policies do not set a homogenous standard for land rights throughout the country.

The findings from the first two chapters of this dissertation provide important information that can be helpful for policy design. It is important to understand the history and political economy of the HRS to effectively design policy measures to address deficiencies in the system. The paper describes how central government policies generally favor more individualized land-tenure rights for rural households. However, the paper also shows that land-tenure rules in China vary a great deal from village to village. This contradiction implies that central government rules are not all that is necessary to improve land-tenure rights for households, and that it is likely that village leaders play a key role in setting local land-tenure rules.

The motivations of these local officials must be better understood before it will be possible to craft effective national policies to ensure that rural households have appropriate levels of land-tenure rights on their agricultural land. While a full

exploration of the motivation of village leaders in this regard is beyond the scope of this paper, continued research in this area will be important for designing appropriate future land-tenure policies for Chinese agriculture.

TABLE 2.1

SAMPLE POPULATION AND INCOME CHARACTERISTICS

Province and County	Number of Villages in Survey (Number of Households in Survey)	Village Population		Per Capita Net Income (Yuan)		Percent of Household Income from Non-Ag Sources	
		1988	1993	1988	1993	1988	1993
All Villages	83 (800)	1494	1592	999.5	1725.1	27.1	34.0
Zhejiang							
Ning	10 (100)	1370	1610	1118.0	2696.7	51.4	59.4
Leqing	10 (100)	1119	1230	1261.2	2859.4	55.9	63.7
Shaoxing	10 (100)	1017	1064	1029.0	3325.0	62.7	77.8
Henan							
Weihui	10 (100)	670	717	561.0	898.1	9.9	22.2
Jilin							
Dehui	16 (100)	2397	2490	1141.2	1250.0	9.3	11.3
Gongzhuling	16 (100)	1784	1869	1196.7	921.4	8.0	15.2
Jiangxi							
Anfu	6 (100)	1482	1547	881.6	904.7	14.9	16.9
Nancheng	5 (100)	1289	1369	632.0	1045.0	5.1	12.0

Figures are in 1993 Yuan. The Official Exchange Rate in 1993 was Y5.76=US\$1.00

TABLE 2.2

SAMPLE LAND AND AGRICULTURAL PRODUCTION STATISTICS

Province and County	Total Number of Land Parcels per Household		Agricultural Land Per Capita (in mu)		Average Output of Grain (in kg per mu of land)		Percent of Household Output Sold as Grain Quota		Output of Village Firms (100,000 Yuan)	
	1988	1993	1988	1993	1988	1993	1988	1993	1988	1993
All Villages	8.4	7.1	2.4	2.2	722.8	790.7	23.3%	21.9%	148.2	671.6
Zhejiang										
Ning	5.1	4.2	1.1	0.9	764.6	699.8	26.9%	21.0%	664.1	3421.3
Leqing	8.7	7.4	0.5	0.5	760.8	756.1	15.8%	15.0%	70.2	13.1
Shaoxing	2.5	2.1	0.7	0.7	960.1	946.2	13.9%	12.9%	474.0	2103.3
Henan										
Welhui	3.3	3.0	1.6	1.5	463.9	641.2	12.1%	9.7%	0.0	3.6
Jilin										
Dehui	4.8	4.7	4.8	4.7	645.8	755.0	30.3%	25.6%	3.0	7.4
Gongzhuling	3.8	3.5	4.0	3.9	936.5	1131.9	29.4%	32.5%	6.5	1.2
Jiangxi										
Anfu	29.8	24.0	2.4	2.3	401.4	417.3	28.8%	27.1%	4.2	11.4
Nancheng	9.3	6.9	1.8	1.7	555.7	469.7	24.0%	25.6%	7.2	25.5

Figures are in 1993 Yuan. The Official Exchange Rate in 1993 was Y5.76=US\$1.00.

Notes: One Mu=One Fifteenth of a Hectare.

TABLE 2.3

ADMINISTRATIVE LAND REALLOCATIONS 1984-1993

Province and County	Percent of Villages Reallocating Land 1984-1993	Percent of Households Reallocating Land 1984-1993	Mean # of Land Reallocations 1984-1993 (# Conditional on at Least One Reallocation)	Range in # of Land Reallocations Among Villages 1984-1993	Percent of Large Reallocations in Total Reallocations	Average Number of Years Village Households Have Controlled the Land They Farm 1988 (Range)	Average Number of Years Village Households Have Controlled the Land They Farm 1993 (Range)
All Villages	65.0%	33.4%	1.1 (1.7)	0-6	33%	5.2 (0-8)	8.5 (0-13)
Zhejiang							
Ningbo	70.0%	6.0%	1.4 (2.0)	0-4	50%	5.1 (4.4-6)	10.1 (9.4-11)
Leqing	50.0%	40.0%	0.7 (1.4)	0-2	60%	6.1 (4-8)	8.5 (0-13)
Shaoxing	50.0%	50.0%	0.8 (1.6)	0-3	70%	6.1 (5-7)	6.8 (1-11)
Henan							
Weihui	100.0%	100.0%	2.0 (2.0)	1-3	80%	2.0 (0-4)	3.2 (1-8)
Jilin							
Dehui	100.0%	20.4%	1.0 (1.0)	1-1	0%	5.0 (5-5)	9.6 (9-10)
Gongzhuling	6.2%	1.0%	0.1 (1.0)	0-1	0%	5.8 (5-7)	10.8 (10-12)
Jiangxi							
Anfu	83.0%	12.5%	3.3 (4.0)	0-1	0%	6.6 (6.1-6.8)	11.4 (11-11.7)
Nancheng	80.0%	79.5%	1.2 (1.5)	0-3	83%	5.0 (1.2-6.7)	4.6 (1-11)

TABLE 2.4

ADMINISTRATIVE AND MARKET LAND TRANSFERS BY YEAR

	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>
Number of Village Administrative Land Reallocations	8	12	6	5	9	7	12	18	11	5
Percent of Administrative Reallocations Involving all the Village Land (Large Reallocation)	13%	8%	0%	24%	11%	43%	33%	11%	55%	20%
Number of Individual Household Land Market Transactions Reported	-	-	-	1	4	14	38	50	64	86

TABLE 2.5

MEASURES OF LAND-TRANSFER RIGHTS

Province and County	Percent of Villages Reporting Free Transfer Rights		Percent of Households Reporting Free Transfer Rights		Percent of Households Reporting Land Market Activity 1987-1993		Percent of Villages Reporting Land Market Activity 1987-1993		Percent of Households Reporting Land Market Activity in 1993		Number of Land Transfers Reported in 1993	
	1988	1993	1988	1993	1987-1993	1987-1993	1987-1993	1987-1993	1987-1993	1987-1993	1987-1993	1987-1993
All Villages	63.3%	59.7%	68.5%	73.0%	21.9%		63.9%		10.8%		86	
Zhejiang												
Ning	20.0%	30.0%	54.5%	71.0%	41.0%		50.0%		4.0%		4	
Leqing	88.9%	90.0%	85.7%	97.5%	66.0%		90.0%		60.0%		60	
Shaoxing	44.4%	70.0%	30.0%	30.3%	10.0%		30.0%		3.0%		3	
Henan												
Weihui	70.0%	50.0%	32.0%	34.0%	3.0%		10.0%		0.0%		0	
Jilin												
Dehui	100.0%	62.5%	100.0%	100.0%	17.0%		62.5%		8.0%		8	
Gongzhuling	64.3%	40.0%	83.0%	93.0%	15.0%		62.5%		6.0%		6	
Jiangxi												
Anfu	50.0%	50.0%	100.0%	100.0%	17.0%		83.3%		4.0%		4	
Nancheng	20.0%	100.0%	63.0%	63.0%	6.0%		40.0%		1.0%		1	

TABLE 2.6

MEASURES OF LAND-USE RIGHTS

Province and County	Percent of Households Reporting the Right to Freely Plant Crops		Percent of Households Reporting the Right to Freely Sell Crop Output		Percent of Households Reporting the Right to Use Land As Collateral		Percent of Households Reporting the Right to Inherit Land	
	1988	1993	1988	1993	1988	1993	1988	1993
All Villages	84.9%	91.4%	65.7%	77.8%	2.0%	1.6%	45.4%	46.0%
Zhejiang								
Ning	79.3%	94.0%	60.6%	92.0%	4.0%	1.0%	41.4%	33.3%
Leqing	99.1%	90.0%	91.9%	90.0%	0.0%	0.0%	90.8%	88.8%
Shaoxing	71.0%	80.0%	70.0%	79.0%	0.0%	0.0%	0.0%	1.0%
Henan								
Weihui	81.0%	79.0%	81.0%	80.0%	0.0%	0.0%	28.0%	30.0%
Jilin								
Dehui	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	100.0%	99.0%
Gongzhuling	65.6%	91.3%	52.0%	90.4%	12.0%	12.0%	58.0%	71.0%
Jiangxi								
Anfu	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Nancheng	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	46.0%	46.0%

CHAPTER 3: LAND-TENURE INSTITUTIONS AND AGRICULTURAL PRODUCTIVITY: A COBB-DOUGLAS RESTRICTED PROFIT FUNCTION APPROACH

SECTION 3.1 INTRODUCTION

The impact of land-tenure arrangements on agricultural production is a subject that has been studied by economic researchers in a variety of contexts and countries around the world (Besley 1995; Kevane 1996; Place and Hazell 1993; Blarel 1990; Roth et al 1993; Rozelle et al 1998; Carter and Yao 1998). These studies typically employ either an investment-demand or plot-yield function in an attempt to discern the impact that land-tenure institutions such as poor tenure security may have on agricultural yields or investments in long-term land improvement. However, as shown by Pan Yotopoulos and Lawrence Lau, the single-equation analysis used in these studies suffer from simultaneous-equations bias and inconsistency (Yotopoulos and Lau 1979). To overcome these problems, Yotopoulos and Lau proposed using duality theory in the form of a restricted profit function to achieve statistically consistent estimates of production parameters.

The impact of land tenure on agricultural production has been a key focus of the profit-function approach since its inception. For example, the seminal paper by Lau and Yotopoulos outlining their methodology focused on differences in production efficiency between small and large farms in India (Lau and Yotopoulos 1971). Since that time, researchers have addressed a variety of questions related to land-tenure

institutions using the profit function approach. Studies have examined the impact on agricultural production of factors such as farm size, land ownership and rental arrangements (Lau and Yotopoulos 1972; Yotopoulos and Lau 1973; Yotopoulos and Lau eds. 1979; Trosper 1978; Kumbhakar and Bhattacharyya 1992; Wang et al 1996). However, to date no papers have addressed the impact of important land-tenure issues such as land-tenure security and farm fragmentation on agricultural productivity. Thus far, these important issues have only been addressed in a single equation format such as those described above.

This chapter adopts the Cobb-Douglas restricted profit-function methodology developed by Lawrence Lau and Pan Yotopoulos to test the impact on agricultural productivity of several important aspects of land-tenure arrangements in China. It is the first paper to utilize duality theory to study the productivity implications of issues such as land-tenure security and land fragmentation. It is also one of the first applications of this methodology to Chinese agriculture. The goal of the paper is to gain a better understanding of how land-tenure institutions in China affect agricultural production. The knowledge gained from this work can be used to develop improved policies that will allow gains in agricultural production through the more efficient use of existing resources.

This chapter is organized in five main sections after the introduction. Section 3.2 includes a literature review covering previous applications of the profit-function methodology, and previous works that explore the impact of land-tenure institutions on agricultural production in China. Section 3.3 introduces the methodological framework used in profit-function analysis, focusing on a Cobb-Douglas production function specification and offers an application of the Cobb-Douglas profit function to Chinese agriculture. Section 3.4 covers the data set and regression specifications used

in the empirical analysis, and discussion of several sets of estimation results. Finally, Section 3.5 offers conclusions and suggestions for further research.

SECTION 3.2 LITERATURE REVIEW

3.2.1 INTRODUCTION

Duality theory has been used to study production efficiency in a variety of agricultural and non-agricultural settings. Studies have looked at production efficiency in a wide variety of fields, including agriculture, the electric power generating industry, the American airline industry and heavy industry in the Soviet Union⁹. Duality theory includes the examination of either restricted profit functions or restricted cost functions that are the dual of the production function.

Several advantages exist for using the dual profit or cost function rather than the attempting the direct estimation of the production parameters. For example, Yotopoulos and Lau have shown that direct estimations of production function parameters using ordinary least squares estimators may be subject to simultaneous equations bias and inconsistency (Yotopoulos and Lau 1979). In addition, the use of the duality theory allows the derivation of systems of demand equations, even when flexible functional forms such as the translog are used (Halvorsen 1978). Derivation of the demand functions allows for the simultaneous estimation of the demand equations together with the profit or cost equation. The simultaneous estimation of the system of related equations increases the degrees of freedom available when compared to a

⁹ See Halvorsen (1978) for a listing of a number of early studies. Other studies include: Atkinson and Halvorsen (1980, 1984, 1997; Toda 1976); Stefanou and Saxena (1988); Kumbhakar and Bhattacharyya (1992); Atkinson and Cornwell (1993,1994, 1994); Ali et al (1994); and Wang et al (1996).

single-equation regression. This results in more efficient and consistent parameter estimates.

As outlined by Lau and Yotopoulos, estimations employing duality theory permit the measurement of three types of production efficiency (Lau and Yotopoulos 1971). The first can be referred to as technical efficiency. It measures the ability of firms to turn a given set of inputs into output. When comparing two firms, the firm that can produce a larger amount of output from a given set of inputs is considered to have greater technical efficiency. Second is the concept of price efficiency. Price efficiency measures the ability of firms to profit maximize by equating the value of the marginal product of each variable factor of production to its price. Third is the concept of economic efficiency. Tests of relative economic efficiency between firms take into account the first two types of efficiency, plus the fact that different firms operate at different sets of market prices. If firms have varying degrees of technical and price efficiency, but face an identical set of prices, then the firm with higher profits within a certain range of prices is considered to have higher relative economic efficiency.

Almost all of the applications of duality theory to the study of agricultural production have utilized a restricted profit-function approach. Lawrence Lau and Pan Yotopoulos have been directly or indirectly involved in most of the studies in this field. The methodology outlined in their seminal work on India has been applied to a diverse set of countries and situations, including studies of Taiwan, Malaysia, Turkey, Thailand, pre-Revolutionary China and American Indian ranching (Yotopoulos and Lau eds. 1979; Trosper 1978; Brandt 1987). The methodology they employ utilizes a Cobb-Douglas functional form for production. Other researchers have used alternative functional forms, such as the translog, in their studies of agricultural production efficiency (Kumbhakar and Bhattacharyya 1992; Ali et al 1994; and Wang et al 1996).

Either functional form permits the construction of various tests of relative and absolute price, technical and economic efficiency among farm households.

Four published studies utilizing a restricted profit function approach have been conducted using data from China. Three papers focused on Chinese agriculture, and one paper explored allocative and technical efficiency in the Chinese construction industry (Parker 1992). Two of the agricultural papers were historical in nature, and used data from pre-Revolutionary Chinese agriculture (Brandt 1987; Lau et al 1979). Only one paper has used a profit function approach to study contemporary Chinese agriculture (Wang et al 1996). The methodology, empirical specification and results of the three of the papers on Chinese agriculture are explored in more depth later in this section.

The literature review provided in this section focuses three main topics. First, it examines previous applications of the profit-function approach popularized by Lau and Yotopoulos with a focus on studies related to China that adopt this methodology. Second, it considers other applications of duality theory, and explores how these techniques have been employed in empirical estimations. Once again the focus is on papers related to Chinese agriculture. Third, the literature review will cover several papers that have explored the link between land-tenure institutions and agricultural productivity in China using methodologies not related to duality theory. As only one paper has used the profit function approach to study contemporary Chinese agriculture, these papers offer the only direct look thus far at the link between land-tenure institutions and agricultural productivity.

3.2.2 APPLICATIONS OF THE LAU AND YOTOPOULOS METHODOLOGY

STUDIES WRITTEN OR OVERSEEN BY LAWRENCE LAU AND PAN YOTOPOULOS

Lawrence J. Lau and Pan A. Yotopoulos were two of the earliest researchers to develop and apply the restricted profit function analysis to agriculture. They published a series of papers in the 1970's outlining their methodology and applying it to a study of the relative and absolute efficiency of small farms and large farms in India (Lau and Yotopoulos 1971; Lau and Yotopoulos 1972; Yotopoulos and Lau 1973). The methodology developed by Lau and Yotopoulos is described in Section III of this paper. This sub-section of the paper briefly describes several empirical applications of the methodology carried out by Lau and Yotopoulos and other researchers. It offers a critique of their results, and discusses how the results of these studies might apply to the current study.

The initial application of the restricted profit function methodology carried out by Lau and Yotopoulos focused on differences in production efficiency among small and large farmers in India (Lau and Yotopoulos 1971; Lau and Yotopoulos 1972; Yotopoulos and Lau 1973). All three published studies used the same set of data and the same regression specification. In the studies, three inputs in the production process were identified, a variable input, labor, and two fixed inputs, land and capital. Dummy variables were used to divide the sample into groups of small and large farmers, and tests were conducted to check the relative and absolute efficiency of each group of farmers. The primary findings of the papers were that in the areas of India studied, small farms were relatively more economic efficient than large farms, although both groups were equally price efficient. Lau and Yotopoulos concluded that small farms have higher actual profits than large farms due to higher technical efficiency. They postulated that the greater direct supervisory and leadership role of the small farm owner was the most likely source of the difference in technical efficiency.

Following the publication of their initial paper, Lau and Yotopoulos collaborated with other researchers to apply a similar methodology to a variety of countries and institutional arrangements. Summary papers from several of these studies can be found in a special edition of the Stanford Food Research Institute Studies entitled, "Resource Use in Agriculture: Applications of the Profit Function to Selected Countries" (Yotopoulos and Lau, eds. 1979). Studies included in the volume apply the profit-function approach to a diverse set of situations, including applications in Taiwan, Turkey, Japan, Thailand, Malaysia, and pre-Revolutionary China. Several of these works test for relative and absolute production efficiency among specific groups of farmers. The groups identified include farm owners versus rental tenants in northeast China and Malaysia; farmers using early and late-tillage production procedures in Turkey; and farmers across two different time periods in Taiwan.

Many of the results of the papers included in the volume were consistent across countries and groups. For example, the hypothesis of absolute profit efficiency could not be rejected for any of countries or groups in the studies. In addition, in contrast to the earlier findings for India, none of the papers in this study found significant differences in production efficiency between identified groups of households. Based on these results, the editors of the study conclude that if significant shortfalls in economic efficiency did exist, both absolutely and within groups, such inefficiencies would rapidly disappear if markets are active and efficient. For example, if tenant farms were more efficient than rental farms, one would expect that tenant farms would be able to bid land away from the rental market until efficiency levels between the two groups were equalized.

As noted by the editors, the consistency of the findings of these studies is quite remarkable given the diversity of countries and situations studied. The studies seem to imply that contrary to much research on developing country agriculture, agricultural

households and markets in most developing countries operate efficiently. However, a closer examination of some of the results described by papers in the volume calls into question some of the researchers' results and conclusions.

The primary area of concern with regard to the papers reported in the study is related to the large reported standard errors in many of the regression models. As described by Loren Brandt (1987), "The large standard errors of the coefficients on the price variables in the profit equation make it very unlikely that a null hypothesis of absolute profit efficiency could ever be rejected." In the Lau and Yotopoulos methodology, if profit maximization is not rejected, restrictions are placed on the coefficients on the price variables in the equation system. All the studies reported in the Food Research Institute volume fail to reject the hypothesis of profit maximization, and therefore impose these restrictions. The restrictions ensure that the coefficients on the price variables have the a priori expected sign (negative). In addition, other restrictions such as constant returns to scale are added to the final regression specifications for most of the studies in the volume.

The various restrictions imposed dramatically alter the reported values of many of the coefficients in the regressions, occasionally changing their signs and often significantly changing the results. For example, in the unrestricted form many of the papers in the volume have positive coefficients on the variable input prices. The restricted regressions in these papers, the form used to report final results, all report negative coefficients on all variable input prices. The estimated coefficients in the restricted case often bear little resemblance to the coefficients obtained in the unrestricted case, but always meet a priori expectations. Reflecting on this finding, the editors' remark, "It is especially encouraging that the estimated coefficients in all the studies are consistent with a priori expectations with regard to both signs and

magnitudes.” (Yotopoulos and Lau eds. 1979). However, the authors fail to point out that this result is achieved only through restrictions that require it to be true.

The heart of the problem with the results reported for the studies in the Food Research Institute volume is the low level of significance on most of the regressions in the volume. This low level of significance allows the imposition of restrictions that ensure expected results. The uniformity in results achieved in this volume, therefore, might be seen not as evidence of the successful application of the profit-function approach as claimed by the authors, but rather as a weakness of the studies. Yotopoulos and Lau themselves comment,

“Obviously the estimates reported in this volume were not the only ones attempted. Like in many other cases of econometric research, some early runs produced dry holes. These are not commonly reported, for the same reason that “Dog Bites Man” does not make news! Both theory and empirical research lead to strong priors in relation to certain ‘regrettable hypotheses’ – such as the downward slope of the demand curves for inputs. The application of Occam’s razor to results contrary to these hypotheses suggests that errors in the data, in measurement and in techniques may be the culprits for failure. ‘Data massaging’ in these cases typically consists of successive iterations in specification until the results come out right.”

While achieving a priori expected results is a goal of empirical research, valid research does not restrict the results to only meet the expected hypothesis.

A closer look at one of the papers in the Food Research Institute volume offers an explanation for why many of the results in studies are on shaky ground, and provides some information on Chinese agricultural conditions. The paper of focus was written by Lawrence Lau, Raymond Myers and Erwin Chou and entitled, “Economic

Efficiency of Agricultural Production in Northwest China, circa 1940.” (Lau et al 1979). It uses data gathered in 1940 and 1941 by the Manchukuo Bureau for Agriculture Promotion for 67 farms in Manchuria in northern China. The paper applies a Cobb-Douglas restricted profit function approach. It identifies one variable input, labor, and two fixed inputs, household capital and land. The study includes tests of households with five land tenure types: households owning and farming their own land; landlord households with substantial holdings of land; households that both own and rent land, with owned land being greater; households that both own and rent land, with rented land being greater; and finally households that are pure renters. Each tenure type is exclusive in that households can belong to only one land tenure grouping.

The study found that all specified groups profit maximize, both absolutely and relative to other groups, and all groups have equal technical and price efficiency. These findings may be due, however, to the small sample size and resulting imprecise estimates of the parameters. The total sample included only 67 farms, and these farms were divided into the five groupings outlined above. In the reported results, the coefficient on the variable input price of labor in factor-share equation was approximately 15 times larger (in absolute values) than the coefficient on the variable input price of labor in the profit equation. However, due to the imprecise nature of the estimation results, the hypothesis of profit maximization was not rejected¹⁰. Many of the other studies in the Food Research Institute volume also contain very small sample sizes. With small sample sizes, it is difficult to obtain significant results, particularly

¹⁰ The test of profit maximization involves an F-test of the probability that the two coefficients estimated for the variable input prices are equal. Despite the wide variation in the coefficients estimated in this analysis (the coefficient in the profit function is -0.41 and the coefficient in the factor share equation is -6.03), this hypothesis can not be rejected, even at the loosest standard level. After not rejecting the hypothesis, the authors re-estimate the system imposing a restriction that the

when the sample is divided into many smaller sub-groups. The impact of sample size can be seen in the results of a second study from pre-Revolutionary China that carries out an almost identical analysis, but uses a much larger sample size.

STUDIES BY OTHER RESEARCHERS

Utilizing data gathered in Manchuria by the Japanese South Manchurian Railroad in the late-1930's, Loren Brandt carried out a similar restricted profit function study of agriculture in northern China. While the number of households used in the final estimation procedures is not identified, the surveys collected information on approximately 450 households in three village areas. Rather than dividing the data into many smaller groups, he tests primarily for differences in economic efficiency between large and small farms. In his estimations, he uses two variable factors of production, labor and draft animal services, and two fixed factors, land and household capital. His reported standard errors are much smaller than those reported in the previous study, and more variables are statistically significant. His findings, therefore, may be considered more robust.

The results of the Brandt study indicate that large farms were more technically efficient than small farms, although both groups profit maximize to the same degree and are equally price efficient. He interprets this finding as an indication that markets worked relatively well in the areas studied, and both small and large farms applied inputs only to the point where the marginal benefit of inputs equaled the market cost. His investigation of why large farms were technically superior to small farms ruled out possible scale effects, as his study reported constant returns to scale, and focused on the effect of land fragmentation on farm production.

two coefficients are identical. The coefficients in the restricted equation are -0.42, a fifteen-fold change in the estimated coefficient for the factor share equation.

While he did not explicitly include land fragmentation as a variable in his analysis, his survey showed that small, family farms typically included a number of dispersed plots, while larger farms were often made up of contiguous land areas. He hypothesized that land fragmentation among small farms hindered the rational use of land, capital and other inputs. Brandt's findings of greater technical efficiency for large farms and the impact of land fragmentation in pre-Revolutionary China provide an interesting comparison point for post-collective Chinese agriculture, which emphasizes household-based production systems similar to those present prior to the Chinese Communist Revolution.

One final paper that applied the Lau and Yotopoulos methodology to agriculture is Ronald Trosper's study of American Indian and Anglo ranchers in Montana (Trosper 1978). His tests for equal relative economic efficiency between the two groups of ranchers initially found higher efficiency for American Indian farmers. Further testing, however, revealed that when the portion of household land that is rented was controlled in the regressions, American Indian ranchers and their white counterparts have equal technical and price efficiency and profit maximize to the same degree. His study is seen as evidence that American Indian ranchers do not have lower levels of technical efficiency than Anglo ranchers, contrary to the beliefs of many observers. The results of this study, however, have been criticized by Brandt due to weak significance of the reported parameters (Brandt 1987).

Several similarities can be seen in the results of all the studies reported above that have applied the Lau and Yotopoulos profit maximization methodology. For example, all the studies can not reject a hypothesis of absolute profit maximization for the households or sub-groups of households studied. The papers also generally find little difference in either price or technical efficiency between the different sub-groups considered in their estimations. The one exception was Brandt's finding of relative

large-farm efficiency in China. However, consistency of results, especially across a diverse set of countries and environments, is not necessarily a demonstration of success. In fact, it may be evidence of weaknesses in the testing procedure, as is demonstrated in the almost impossibility with regard to the rejection of profit maximization displayed by these studies.

More recent papers, several of which are described in the following discussion of papers that apply duality theory methodologies that differ somewhat from the Lau and Yotopoulos approach, have found absolute profit maximization to be the exception rather than the norm. The acquisition of larger, more precise data sets may be a factor in this change in results. Improvements in estimation techniques may also be helpful in improving the reliability of the coefficients estimated and the conclusions reached in the studies. The following sub-section of the literature review briefly discusses several attempts by researchers to improve the specification and reliability of the restricted profit function and related estimation procedures.

3.2.3 OTHER APPLICATIONS OF DUALITY THEORY

As was mentioned earlier, a broad literature exists for using duality theory in the study of production efficiency. Rather than attempt to review the entire literature in this broad field, this sub-section of the paper describes some of the key aspects of the analysis and methodologies used by researchers other than Lau and Yotopoulos. It also looks at one aspect of the Lau and Yotopoulos methodology that is rarely addressed in their empirical work, the issue of shadow price calculations.

ALTERNATIVE METHODOLOGIES AND EXTENSIONS OF THE LAU AND YOTOPOULOS
COBB-DOUGLAS FRAMEWORK

One aspect of the Lau and Yotopoulos methodological framework that is scarcely mentioned by Lau and Yotopoulos in their empirical work, but is at the heart of several other studies, is the estimation of shadow-price parameters. As outlined in Section III, the Lau and Yotopoulos methodology estimates a behavioral profit function that incorporates shadow-price parameters into the profit maximization framework. However, one of the conditions of profit maximization in their framework is that all of the shadow-price parameters on variable inputs in the equation are equal to one. This implies that shadow prices are equivalent to observed prices. Therefore, the analysis of the shadow-price parameters becomes trivial if profit maximization is not rejected for a sample. Because all of the published applications of the Lau and Yotopoulos framework have not rejected profit maximization, no published study has used the Lau and Yotopoulos methodology to calculate shadow-price parameters.

Other authors, however, employing slightly different methodological approaches, have generally rejected the hypothesis of absolute profit maximization for their samples (Atkinson and Halvorsen 1980; Atkinson and Halvorsen 1984; Ali et al 1994; Kumbhakar and Bhattacharyya 1992; Wang et al 1996). If profit maximization is rejected, shadow prices will differ from observed prices and examination of the shadow-price parameters can lead to valuable insights into aspects of production efficiency. For example, Atkinson and Halvorsen (1980) rejects absolute profit efficiency behavior among firms in the regulated electric power generating industry, while Atkinson and Halvorsen (1984) obtains similar results using a cost function approach. These papers directly estimate the shadow-price parameters using a restricted profit or cost system approach. Estimation of the shadow-price parameters provides information on the impact of regulations on the use of inputs and production

efficiency in the electric power generating industry. Similar approaches are possible using the Lau and Yotopoulos methodology, but have not been carried out due to non-rejection of profit maximization in earlier studies.

One difference between the Lau and Yotopoulos estimations and those of Atkinson and Halvorsen and other researchers is the choice of functional form used to represent production. While Lau and Yotopoulos relied on a Cobb-Douglas functional form, many other studies utilize a transcendental logarithmic (translog) functional form. As Atkinson and Halvorsen (1980) explain, "The use of the translog functional form for the behavioral normalized profit function provide tests of efficiency that are subject to minimal a priori restrictions on profit maximizing behavior. The more restrictive Cobb-Douglas behavioral profit function used by Yotopoulos and Lau (1973) is a special case of the translog in which all the [coefficients on terms across variable factors] are constrained to be zero." However, the translog form has fewer degrees of freedom available due to the necessity of estimating a large number of cross-terms. The significance of these cross-terms in the regression will determine which functional form is the best to use in empirical estimations. A later chapter of this dissertation employs a translog functional form. Tests for the superiority of one functional form over another are conducted, but the hypothesis that the two forms are equally efficient can not be rejected.

Several recent papers have utilized panel data to increase the efficiency and range of their estimation results. For example, in the Atkinson and Halvorsen and Lau and Yotopoulos methodologies described, the shadow-price parameters are input specific, but identical across firms in the sample. It is also not possible using these methodologies to simultaneously estimate price and technical efficiency. Panel data approaches permit the estimation of firm-specific shadow-price parameters and the simultaneous estimation of technical and price efficiency parameters. However, these

approaches require that the number of time periods covered by the data set must be large compared to the number of firms included in the study. Rigorous data requirements limit the applicability of panel data techniques, but the approach can be useful when appropriate data is available. Atkinson and Cornwell, for example, applied their panel data techniques to studies of production efficiency in the U.S. airline industry (Atkinson and Cornwell 1993, 1994a, 1994b).

In the end, the decision about which functional form to use and what techniques of analysis to employ are determined by the availability of data and the appropriateness of the empirical specification to question being studied. Many of the more recent techniques require large cross-section data sets or deep panel data sets. In addition, the technical and computer resources necessary to program complex, iterative, non-linear seemingly unrelated regression systems and other necessary techniques are not always available. While researchers would generally like to apply the most sophisticated research techniques available in all cases, at times it is necessary to adopt appropriate technologies for the data and situations under examination.

3.2.4 APPLICATIONS OF ALTERNATIVE PROFIT-FUNCTION METHODOLOGIES IN AGRICULTURE

Several recent studies of agricultural production in a variety of developing countries have adopted methodologies similar to those described above in that they employ translog functional forms and some attempt to measure farm-specific shadow-price parameters. For example, Ali et al (1994), Kumbhakar and Bhattacharyya (1992) and Wang et al (1996) all use farm household data to test for profit maximization and technical efficiency in developing country agricultural production. The data sets used in these studies come from Pakistan, India and China, respectively. Because all three

papers follow a similar methodology, the following discussion will focus on the study of Chinese agriculture conducted by Wang et al.

The sample data set used in the study by Wang et al was taken from a sub-sample of China's National Rural Household Survey for 1990. After excluding households with no farm land or labor, and households reporting negative profits, 1889 households in 55 counties across China are included in the study. Two outputs (crops and livestock), two variable inputs (chemical fertilizer and other purchased inputs) and three fixed factors (labor, land and capital) are included in the empirical regression system. The original survey contained no price variables, therefore all price variables were imputed using quantity, revenue and expenditure variables. For households that did not use a particular input, missing prices were set at the average of the provincial level prices.

This study tests price efficiency by estimating a restricted translog profit system in which all shadow-price parameters are constrained to equal one. It then compares the log likelihood of this model to the log likelihood of an unrestricted model in which the shadow-price parameters are allowed to differ from one. Based on the results of this likelihood-ratio test, the paper rejects the notion of profit maximization at observed prices. It finds that shadow prices differ significantly from observed prices, and households are generally neither price nor technically efficient at observed prices. The two other papers reported similar findings for Pakistani and Indian agriculture.

Based on these findings, the paper attempts to find factors that influence the technical or price efficiency of households. In China the study finds that large farms are more technically efficient than small farms, and lower-educated households are less technically efficient than higher-educated households. The authors compute farm-

specific values of the shadow-price parameters and relate these to household characteristics to understand how such characteristics affect input and output use. They find that characteristics such as household's education level and the farm's labor-land ratio influence the allocation of household output and input.

One application that is possible using the estimated shadow-price parameters is a test of whether households are using or producing more or less than the profit maximizing amount of the variable inputs and outputs. In all three studies the shadow prices of most variable inputs are found to be less than their marginal costs, and the shadow prices of most outputs are also found to be less than their marginal costs. These results indicate that in all three of these developing countries agricultural households tend to use fewer inputs than profit maximization would imply, and produce less output than would be expected if the households were profit maximizing. The only exception to this finding was in China, where households were found to produce more output of both crops and livestock than profit maximization would imply. The authors attributed this finding to market restrictions in China such as crop output quotas that force Chinese households to increase their production of certain outputs.

The papers on China and Pakistan both extend their analysis by estimating second-stage regressions after completing the first-stage estimation procedure. In the paper on China, the authors employ a shadow-price profit frontier approach in the second-stage in an attempt to gain further information on the relative profit efficiency of households. They find that inefficiency accounts for an average 38.9 percent loss of profits among the households surveyed. The paper attempts to decompose factors such as location, farm size, outside employment and other variables that might influence household relative profit efficiency. The results from this work indicate that an increase in family size and income tends to increase agricultural productivity, while

off-farm work, being a member of a minority people or living in a mountainous or coastal area tends to be associated with lower agricultural productivity. The authors conclude by suggesting that increasing farm size in China and allowing scarce resources such as farmland to transfer through markets should increase production efficiency.

3.2.5 NON PROFIT-FUNCTION EFFORTS TO MEASURE THE IMPACT OF LAND-TENURE VARIABLES ON AGRICULTURAL PRODUCTION

INTRODUCTION

The previous sub-sections outlined three papers that have looked at Chinese agriculture using a variation of the profit-function approach. These papers included two historical papers, one by Brandt (1987) and one by Lau et al (1979), and one contemporary work by Wang et al (1996). All of these studies included some analysis of land-tenure rights in their studies of agricultural production. For example, the two historical studies included variables representing various combinations of owned and rented land to test if ownership status affected agricultural productivity.

Both studies rejected the hypothesis that farmers who rented land displayed differences in technical or price efficiency from farmers who owned land. Brandt did find, however, that large farms displayed greater technical efficiency than small farms, a result he hypothesized to be related to land fragmentation among small farms. In contemporary Chinese agriculture, Wang et al also found large farms to have superior technical efficiency. However, while variables related to land tenure were included in each of these studies, none of the studies directly addressed the aspects of land tenure, such as land-tenure security, that have been the focus of the main literature connecting land-tenure rights and agricultural productivity in China and other countries.

In the broader literature on land-tenure rights, several methodologies other than duality theory have been used to connect land-tenure institutions and agricultural production. For example, Shaban (1987) used a fixed effects approach to test for differences in input and output intensities on owned and sharecropped land in India. Besley (1995) and Place and Hazell (1993) studied indigenous land-tenure systems and land-tenure security in Africa to examine the links between property rights and agricultural investment and production.

Two attempts have been made to directly link land-tenure security with investments in land and agricultural production. One study, by Michael Carter and Yao Yang, attempts to measure the impact poor land-tenure security may have on investments in long-term land improvements such as the digging of water wells and land leveling (Carter and Yao 1998). The other study, by Scott Rozelle, Li Guo and Loren Brandt, looks at the impact of poor land-tenure security on investments made by Chinese farmers in long-term soil building through the application of organic fertilizers (Rozelle et al 1998; Li 1998).

All of these studies attempt to directly test the impact of land-tenure variables on the amount of investment made households and/or the amount of production harvested from a household's land holdings. They employ single-equation regression procedures and include total production or investment as the dependent variable. However, as was described earlier, these estimation procedures can be subject to simultaneous equation bias and inconsistency. Despite potential biases, it is important to review the findings of these works because they offer the only direct tests of land-tenure variables such as those used in the empirical section of this paper. The remainder of this sub-section examines these papers and their findings as part of the necessary background review prior to the empirical application considered later in this paper.

EMPIRICAL STUDIES OF LAND-TENURE INSTITUTIONS AND CHINESE AGRICULTURAL PRODUCTION

As discussed in more detail in Chapter 1 of this dissertation, poor land-tenure security is expected to reduce the amount of long-term investment farmers are willing to make on the agricultural land. In China, poor tenure security is primarily created by periodic land reallocations carried out by local government officials in some villages. These reallocations shuffle land between village households so that farm plots that household plants are one season may be reallocated to another household the next season. The original household is typically not compensated for any longer-term improvements it makes to the land plots.

It has been hypothesized that farmers in villages that reallocate land would be expected to make fewer improvements to their land than farmers in areas with permanent, secure land title. Administrative land reallocations usually take place in the off-season; therefore the use of single-season inputs, such as most chemical fertilizers, are not affected. The use of longer term inputs, however, such as manure treatments that yield soil improvements over the course of several years or physical improvements such as land leveling or drainage improvements, are expected to be lower due to uncertain future rights. The lower level of land improvements creates inefficiencies because inputs are not allocated in their most productive manner. Farm households are not free to choose their optimal bundle of agricultural inputs.

Michael Carter and Yao Yang (1998) attempt to directly measure the impact of land-tenure security on long-term investment. They estimate an equation with hours of work reported by households for long-term investment projects such as digging wells, ditches, ponds etc. on the left-hand side, and various household and village characteristics including a measure of land-tenure security on the right-hand side. The data set they use in their estimations is the same as the one used in this paper. They

hypothesize that poor tenure security will reduce the input hours households will provide for land improving investments.

Their results indicate that households in villages with past reallocations of land did work significantly fewer hours on long-term investments than households in villages that did not experience land reallocations. They go on to estimate a direct Cobb-Douglas production function with the number of investment hours included as an explanatory variable on the right-hand side of the equation. Based on the results of the first equation and the estimated production function parameters, they conclude that the lower levels of long-term investment in land by households in villages that have undergone administrative land reallocations reduces agricultural output by approximately 6.9 percent.

While the results of this study appear to confirm the link between land-tenure security and reduced investment in land, the methodology used in the study is problematic on several counts. In addition to the problems related to estimating a direct production function noted earlier, the study only looks at reported hours of investment by households and does not attempt to measure the value of the investments. The paper also notes that few households made investments in the time period studied, complicating the analysis. Several other studies have shown that in China decisions about investments in irrigation systems drainage land terracing, precisely the types of investment measured in the Carter and Yao paper, are usually made at a village rather an individual household level (Li 1998; Dong 1996). If this is true, then the number of hours invested may not be freely decided by individual farmers as is assumed in this study. The study also does not look at households' use of other inputs such as chemical fertilizers that may be substitutes or compliments to land investments. Farmers might substitute more short-term inputs to replace long-term

inputs, or short-term inputs may be enhanced by investments in irrigation or other long-term improvements.

Li Guo, Scott Rozelle and Loren Brandt lead a second study that attempts to measure the impact of land-tenure security on household investment decisions in China (Rozelle et al 1998; Li 1998). These researchers use two different techniques to test the linkage between input intensity and land-rights measures. The first technique is known as the differencing method, and was pioneered by Shaban (1987) to look at the differences in input and output intensities among sharecroppers and fixed-rent tenants in India. This procedure utilizes the fact that households often hold more than one plot of land with different property rights. For example, farmers in China usually hold land of two different tenure types, private plots and responsibility plots.

Private plots are small plots of land on which households have very secure tenure rights. The existence of such plots dates back to the collective period of agriculture when families used them to grow food for their own consumption. Responsibility plots were the plots received by households under the Household Responsibility System. Land reallocations typically only affect responsibility plots, not private plots. By differencing away all factors that are not plot specific, such as household characteristics, the method attempts to directly measure the impact of land tenure and property rights on observed differences in input intensities on the two types of land.

A second method attempted by the researchers is called the input-demand method. It tests input use directly to gauge the impact of land-tenure variables on input use. In this case, the approach is similar to the Carter and Yao paper. However, the Rozelle, Li and Brandt estimations contain additional control variables, such as land-quality indicators. The studies also attempt to control for the quantities of short-term

inputs used by households, such as chemical fertilizers, to limit the effects of substitution and complementary inputs.

Both techniques used in the study both find that poor land-tenure security does have a detrimental impact on the use of long-term inputs. Like the Carter and Yao paper, this paper also ran a direct Cobb-Douglas production function to estimate the magnitude of production lost due to land-tenure insecurity. It found that despite the reduction in the long-term input use caused by land-tenure insecurity, the actual impact of land tenure insecurity on production was small. It predicted a 7.0 percent rise in production if land-tenure security, as measured by the length of land possession, was doubled from current levels (from an average of 8 to 16 years).

While the magnitude of their findings were in line with those of Carter and Yao, the authors note that the impact on production in China attributable to land-tenure factors was much smaller than that found by Shaban in India. Shaban estimated the cost of sharecropping versus fixed-rent tenancy to be approximate 40 percent of total production (Shaban 1987). The study concludes by stating that while land-tenure insecurity does apparently affect input use in China, it does not seem to have a large impact on production due to the low yield elasticity of long-term inputs.

The results of both studies of Chinese agriculture highlighted here seem to confirm the existence of a link between long-term land improving investments and land-tenure security. While the studies can be criticized on econometric grounds, the findings do provide an indication that land-tenure rights play a role in household decisions on input and output use and agricultural productivity. In an effort to gain a better understanding of the link between land-tenure rights and agricultural production, the following three sections of the paper provide an empirical application of the profit-function methodology to Chinese agriculture.

The empirical specifications outlined attempts to fuse the profit-function approach with aspects of land-tenure security adapted from the land-tenure literature described above. It utilizes both Cobb-Douglas and translog functional forms, and includes measures of several of the most important land-tenure issues in China, such as land-tenure security, land fragmentation and farm size. It is the first paper to explicitly examine the production impact of land-tenure security in China using a profit-function approach. Utilizing this approach should help in avoiding the bias inherent in the single-equation estimations utilized thus far in studies of land tenure in China.

SECTION 3.3 THE COBB-DOUGLAS METHODOLOGICAL FRAMEWORK

3.3.1 INTRODUCTION

The basic methodology adopted in the empirical section of this paper was developed by Pan A. Yotopoulos and Lawrence Lau of Stanford. It is outlined in greater detail than is offered in this paper in a number of other studies. Two of the best sources for examining the Cobb-Douglas restricted profit function approach include Yotopoulos and Lau (1973) and Yotopoulos and Lau eds. (1979).

The methodology is based on the duality between the profit function of an agricultural household and the same household's production function. For example, a farm has a production function represented by:

$$(3.1) \quad V = F(X, Z)$$

where V is output, X is a vector of variable inputs, and Z is a vector of fixed inputs in production. The first order conditions for profit maximization with respect to the variable inputs can be given as:

$$(3.2) \quad \frac{\partial F}{\partial X_j} = q_j, \quad j = 1, \dots, m$$

where q_j is the normalized price of the j^{th} variable input. The prices are normalized by dividing the nominal price of each input by the price of output. Equation (3.2) can be solved to yield the demand for the j^{th} variable input of the profit maximizing farm:

$$(3.3) \quad X_j^* = f_j(q, Z), \quad j = 1, \dots, m,$$

where X_j^* is the profit maximizing quantity of the j^{th} input and q is a vector of the normalized prices of the variable inputs.

Restricted profit is defined as the total value of output minus the total cost of the variable inputs of production. The costs of the fixed inputs are not included because they do not affect the optimal combination of the variable inputs. The restricted profit function can be represented as:

$$(3.4) \quad \Pi = p[V - \sum_{j=1}^m q_j X_j]$$

where p is the price of the output and V is the total amount of output. By substituting (3.1) and (3.3) into (3.4), profit can be expressed as a function of the normalized prices of the variable inputs and the quantities of the fixed inputs:

$$(3.5) \quad \Pi = p[F(f_1(q, Z), \dots, f_m(q, Z), Z) - \sum_{j=1}^m q_j f_j(q, Z)].$$

Normalized restricted profits, Π^* , can be derived by dividing (3.5) by the price of output. Normalized restricted profits are therefore a function of only the price of the variable inputs, q , and the amount of the fixed inputs, Z . This is represented by

$$\Pi^* = \frac{\Pi}{p} = G(q, Z).$$

When the production function takes a Cobb-Douglas form, the most common form adopted for studies of agricultural production, then the normalized profit function can be represented by:

$$(3.6) \quad \Pi^* = A^* \prod_{j=1}^m q_j^{\alpha_j^*} \prod_{j=1}^n Z_j^{\beta_j^*},$$

where α_j^* , β_j^* , and A^* are constants.

Applying Shepard's lemma to the normalized profit function, one can obtain the demand functions for the j^{th} variable input by differentiating the normalized profit function with respect to the normalized price of the j^{th} variable input. This is described by:

$$(3.7) \quad -\frac{\partial \Pi^*}{\partial q_j} = X_j^*.$$

The output supply function can be obtained by substituting Equation (3.7) into Equation (3.4) and solving for output:

$$(3.8) \quad V^* = \Pi^*(q, Z) - \sum_{j=1}^m \frac{\partial \Pi^*}{\partial q_j} q_j.$$

3.3.2 EMPIRICAL SPECIFICATION

The empirical specification of equations 3.6 to 3.8 can be represented by a generalized Cobb-Douglas normalized restricted profit function and related demand equations with n variable inputs and m fixed inputs. The normalized restricted profit function can be written as:

$$(3.9) \quad \ln \Pi^* = \ln A^* + \sum_i \alpha_i^* \ln q_i + \sum_j \beta_j^* \ln Z_j + \sum_{k=1}^K \delta_k D_k$$

$$i = 1, \dots, n; j = 1, \dots, m; k = 1, \dots, K$$

where Π^* is the restricted profit function (current revenues minus current variable costs) normalized by the price of output. The q 's represent the prices of the n variable inputs, while the Z 's represent the quantity of the m fixed inputs. The D 's are dummy variables, representing different regions or farm attributes. The regional dummies will capture many of the differences in land quality and other unmeasured region specific variables, while the farm attribute dummies can capture differences between groups of farmers as outlined below.

From the demand functions for each variable factor of production as described in (3.7), factor share functions can be derived for each of the variable factors of production:

$$(3.10) \quad \frac{-q_i X_i}{\Pi^*} = \alpha_i^*$$

Finally, to complete the system of equations, the output supply function can be obtained from the definition of normalized profit:

$$(3.11) \quad V = \Pi^*(q_i, Z_i) - \sum_{i=1}^n \frac{\partial \Pi^*(q_i, X_i)}{\partial q_i} q_i.$$

However, in estimating the system of equations specified in (3.9), (3.10) and (3.11), one equation can be dropped, because it can be derived from the normalized profit identity implied by (3.4). Therefore the actual estimation will use only the equations specified in (3.9) and (3.10).

3.3.3 TESTS OF PROFIT MAXIMIZATION AND ECONOMIES OF SCALE

Estimates of all the parameters can be obtained from estimating equation (3.9), while a second set of estimates of the parameters of the variable factors of production can be estimated from the equations implied by (3.10). Under a hypothesis of profit-maximization and price-taking by farms, the parameters for the variable factors of production that are obtained in estimation of (3.9) should be equal to those obtained through estimation of (3.10). Therefore a test of this proposition can be conducted such that:

$$(3.12) \quad H_0: \alpha_i^* = \alpha_i^*$$

If this hypothesis can not be rejected, then the efficiencies of the estimators may be increased by imposing the constraint implied by profit maximization in (3.12) on the system of equations to be estimated.

A test of constant returns to scale can be conducted using the parameter estimates on the fixed factors of production obtained from estimation of (3.9). A hypothesis of constant returns to scale implies:

$$(3.13) \quad H_0: \sum_{j=1}^m \beta_j = 1$$

3.3.4 TESTS OF RELATIVE ECONOMIC EFFICIENCY

Tests of the relative economic efficiency of different farms or groups of farms can be carried out using the profit-function approach. As outlined by Lau and Yotopoulos, relative economic efficiency has three components - differences in technology between farms, differences in price efficiency between farms and differences in effective prices between farms. Technological differences would imply differences in production functions between farms, while price efficiency would refer to the ability of each farm to equate the value of the marginal product of each variable factor of production to its normalized price. Finally, differences in effective prices might result from various market imperfections such as access to material inputs, transportation costs etc.

When testing the relative economic efficiency of two groups empirically, it can be assumed that the two groups of farms of interest have identical production functions up to a neutral multiplicative parameter. For example, Equation (3.1) can be rewritten for two groups as:

$$(3.14) \quad V^1 = A^1 F(X^1, Z^1); \quad V^2 = A^2 F(X^2, Z^2)$$

where A is the group-specific technical efficiency parameter. Farm group 1 is considered more technically efficient if given the same quantity of inputs it produces a larger set of outputs. Such an outcome would imply $A^1 > A^2$.

In the case of price efficiency, a firm is price efficient if it equates the value of the marginal product of each variable input to its normalized price, and therefore maximizes profits. However, comparisons of price efficiency between farms or groups

may be complicated by differences in prices between farms, and the fact that not all farms may be maximizing profits based on nominal prices. Some farms may be reacting to shadow prices, which can be introduced into the analysis through a farm and/or input specific proportion, k , of the nominal farm input price. For two farm groups the demand functions for the variable inputs may be rewritten as:

$$(3.15) \quad \frac{\partial A^1 F(X^1, Z^1)}{\partial X_j^1} = k_j^1 q_j^1; \quad \frac{\partial A^2 F(X^2, Z^2)}{\partial X_j^2} = k_j^2 q_j^2 \quad j = 1, \dots, m.$$

Empirical tests of relative economic efficiency can be derived to test for equal relative technical efficiency and equal relative price efficiency. Tests of absolute price efficiency can also be obtained. The estimating equation will differ from the earlier form only in that specific dummy variables identifying the two groups of interest will be included. If we define D_1 to be the dummy variable identifying group 1 and D_2 to be the dummy variable identifying group 2 (for example group 1 may be large farms while group 2 is small farms), the profit function and factor demand functions to be estimated will be:

$$(3.16) \quad \ln \Pi^* = \ln A^{1*} + \delta_2^* D_2 + \alpha_i^* \ln q_i + \beta_j^* \ln Z_j + \sum_{k=3}^K \delta_k D_k$$

$$i = 1, \dots, n; \quad j = 1, \dots, m; \quad k = 3, \dots, K$$

$$(3.17) \quad \frac{-q_i X_i}{\Pi^*} = \alpha_i^2 D_2 + \alpha_i^1 D_1$$

where $\delta^2 \equiv \ln(A^{2*}/A^{1*})$.

Tests of the various hypotheses can be conducted within and between the two groups identified. Test available include:

A test of equal relative economic efficiency:

$$(3.18) \quad H_0: \delta^{2*} = 0$$

This test can also be stated as $A^{1*} = A^{2*}$ or $\ln(A^{2*}/A^{1*}) = 0$.

A test of equal relative price efficiency:

$$(3.19) \quad H_0: \alpha_i^{*2} = \alpha_i^{*1}$$

A test of equal relative technical and price efficiency:

$$(3.20) \quad H_0: \begin{matrix} \delta^{2*}=0 \\ \alpha_i^{*2} = \alpha_i^{*1} \end{matrix}$$

A test of absolute price efficiency for each group, for example for group 2:

$$(3.21) \quad H_0: \alpha_i^{*2} = \alpha_i^*$$

SECTION 3.4 DATA AND EMPIRICAL SPECIFICATION

3.4.1 INTRODUCTION

Following the methodology outlined in Section 3.3, this section adopts a Cobb-Douglas restricted profit-function approach to test the impact of land-tenure arrangements on economic efficiency in Chinese agriculture. This paper extends previous work outlined in the literature review by applying it to important land-tenure issues in post-1978 Chinese agriculture. It utilizes a unique data set gathered in 80 Chinese villages in 1989 and 1994 to empirically test the impact on agricultural

efficiency of three aspects of land-tenure, land-tenure security, land fragmentation and small versus large farms. The availability of two observations of cross-section data also allows an examination of production efficiency over time.

3.4.2 THE MODEL

The empirical estimations in this section adopt a Cobb-Douglas normalized restricted profit function with three variable inputs, chemical fertilizer, organic fertilizer and machine and animal input hours, and three fixed inputs, land, family labor and household fixed capital. The Cobb-Douglas normalized restricted profit function for this formulation can be written as:

$$(3.22) \quad \ln \Pi^* = \ln A^* + \alpha_i^* \ln q_i + \beta_j^* \ln Z_j + \sum_{k=1}^6 \delta_k D_k$$

$i = F, O, M; j = T, L, K; k = 1, 2, 3, 4, 5, 6$

where Π^* is restricted profit per household (calculated by subtracting current variable costs from current revenue and normalized by the price of output); q_F^* is the price of chemical fertilizer; q_O^* is the price of organic fertilizer; q_M^* is the price of machine and animal inputs; Z_T^* is sown land area of the household; Z_L^* is the household labor force; Z_K^* is the amount of fixed capital per household; D_1 is a dummy variable representing whether or not a village has experienced a land reallocation (1=yes); D_2 is a dummy variable representing land parcel size (1=large parcels); D_3 is a dummy variable representing farm size (1=large); and $D_4 - D_6$ represent three regional dummy variables for Zhejiang, Jilin and Jiangxi respectively.

In addition to the profit function, a demand function can be obtained for each of the three variable inputs. The demand for variable inputs to production can be written as:

$$X_i = \frac{-\partial \Pi}{\partial q_i}; i = F, O, M$$

These demand functions imply three corresponding factor-share equations. The factor-share equations can be written as:

$$(3.23) \quad \frac{-q_F X_F}{\Pi^*} = \alpha_F^*$$

$$(3.24) \quad \frac{-q_O X_O}{\Pi^*} = \alpha_O^*$$

$$(3.25) \quad \frac{-q_M X_M}{\Pi^*} = \alpha_M^*$$

Where X_F is the total amount of chemical fertilizer used by the household; X_O is the total amount of organic fertilizer used by the household; and X_M is the total amount of machine and animal input hours used by the household.

Finally, using the definition of normalized profit one can obtain the final equation in the system, the output supply function. The output supply function can be written:

$$(3.26) \quad V^* = \Pi^*(q_i, Z_j) - \sum \frac{\partial \Pi^*(q_i, Z_j)}{\partial q_i} q_j; i = F, O, M; j = T, L, K.$$

Given any four of the five equations in the system described by equations 3.22 to 3.26, the fifth equation can be derived using the normalized profit identity. The normalized profit identity describes how normalized profits can be obtained from the output supply function and the cost of each input. It can be written as:

$$(3.27) \quad \Pi^* = V + \sum q_i X_i; i = F, O, M.$$

This identity implies that in empirical applications a researcher may drop any one of the five equations described in 3.22 to 3.26 without loss of generality, as the fifth equation result can be derived using the normalized profit identity. Therefore, in empirical application one need only estimate four equations in the previous system rather than estimating the entire system. Equation 3.26 is omitted from the system during actual estimation. The final estimation procedure includes equations 3.22 to 3.25.

3.4.3 *EMPIRICAL APPLICATION*

The data used for this research was gathered from 800 households in 83 villages across eight counties in four provinces of China. Chapter 2 of this dissertation includes a more extensive description of the data, including statistical summaries. The data was gathered in 1989 and 1994 through household and village surveys conducted by the Development Research Center of the State Council of China. Households from the same 83 villages were surveyed in each time period. Approximately sixty-percent of the survey households can be matched between the two time periods. The other 40 percent either cannot be matched or were not included in both data sets.

The data set includes information on four provincial areas with a wide range of development levels, agricultural conditions and land-tenure arrangements. Zhejiang is a rapidly growing region on China's East Coast. As can be seen in Tables 2.1 and 2.2 from Chapter 2, the per-capita land endowment in Zhejiang is small, but the land productivity is high. The primary crop grown in this region is rice. Rural families are fairly well off due to extensive work opportunities outside of agriculture. Jiangxi is located in south-central China. It is also a rice-growing region and has a moderate amount of land available per capita by Chinese standards. Henan is a poor, primarily agricultural region in central China. It has the lowest average per capital income

recorded in the survey, and few opportunities for farmers to work outside of agriculture. The primary crops include rice, wheat, cotton and other crops. Jilin is a province located in northern China where corn is the primary crop grown. Land endowment per person is fairly high, and work opportunities outside agriculture are limited.

Using the information gathered from households in these areas, the variables necessary for an empirical application of the profit maximization framework can be constructed. The original surveys contained no direct measurements of input and output prices. Following Wang et al (1996), all price variables for variable inputs were imputed using information provided by households on the total amount of the variable inputs used and the value of those inputs. These variables were averaged on a countywide basis to obtain consistent estimates within one marketing area. The price variables for households that did not use one or more inputs was set at the county average.

The survey did not contain reliable information on output prices. However, output prices for almost all crops are available from data collected by the Chinese Ministry of Agriculture and published in the China Statistical Yearbook and by the U.S. Department of Agriculture. Through these sources, the prices of all the main crops were available at a provincial level. The prices of other crops were imputed from the data provided by households in the survey. Almost all households produced more than one crop, although the main crop produced in all areas other than Jilin was rice. Rice accounted for approximately 70 percent of total crop output measured by weight. An output price index was obtained by weighting the average amounts and price of crops produced by each household. In the estimation procedure, the prices of all variable inputs and output were normalized by dividing the provincial input and output prices by the household output price. Because of this normalization procedure,

the price and profit variables used in the regression contain both household-level and provincial-level factors.

Three variable inputs that reflect the range of inputs used by farmers were created using information provided in the survey. For example, the variables for chemical fertilizer were constructed by creating a weighted index of the amounts and prices of the various chemical fertilizers used by households in each county. In the survey, the amounts of chemical fertilizers used were recorded in kilograms and standardized to reflect pure content amounts of fertilizer. The chemical fertilizers included in the survey improve productivity for only one season after application. Therefore, the variable for chemical fertilizers is a short-term input in agriculture.

The price organic fertilizer was obtained using a similar procedure. Organic fertilizers primarily consist of manure, but may contain other organic material such as straw and compost applied to the field. Organic fertilizers were measured in tons applied per household in one year. While households often self-provide organic fertilizers, the price used in the estimations reflects the market price for organic fertilizer in that county. Organic fertilizers, in contrast to chemical fertilizers, provide soil-improvement benefits to production over several time periods. Therefore, the variable for organic fertilizers represents a long-term input in agriculture.

Machine and animal inputs were measured in hours of each input. The price variable for machine and animal inputs reflects the weighted price of both machine inputs, such as tractors and cultivators, and animal inputs, such as draft-animal services. The price was determined using information on rental transactions, and self-owned machinery and animals were valued at the appropriate rental rate for that area. The machine and animal services included in this variable are all of a short-term nature, for example plowing and harvesting services.

Profits were determined by subtracting total variable costs from total revenue. The means and standard deviations of household profits for the regression sample as a whole and for individual land tenure groups are reported in Table 3.1. A substantial number of households, especially in 1988, reported negative profits. In 1988, approximately 20 percent of households reported negative profits, while in 1993, approximately 5 percent of households reported negative profits. Most of the households reporting negative profits had small land holdings and low total revenues from agriculture. Therefore, even low levels of household variable input use resulted in negative profits. Due to the necessity of using logged profits in the estimation of the profit function with a Cobb-Douglas functional form, all households with negative profits had to be dropped from the estimation sample. A small number of additional households in both time periods also had to be dropped from the estimation due to incomplete or inaccurate data. In the end, 619 of 800 households were included in estimations using the 1988 data set and 752 of 800 households were included in estimations using the 1994 data set.

The means and standard deviations of the fixed factors of production for the regression sample as a whole and for each land tenure group are presented in Table 3.1. The land variable is the sown area of cropland per household measured in mu¹¹. The labor variable is the total number of household laborers available for agriculture. Household labor are able-bodied adults between 16 and 65 years of age. Total household capital resources for agricultural production were not directly reported in the original surveys. However, estimates of the capital resources available to each household could be obtained using other information in the survey.

¹¹ A mu is a Chinese measurement unit for land. One mu equals 1 / 15 hectare.

For example, the village surveys recorded the total village capital resources available for agriculture at the time when the Household Responsibility System (HRS) was implemented. As all agriculture was collective prior to the advent of the HRS, dividing village resources by the number of village households provides a reasonable proxy for the amount of capital resources available to households at the start of the HRS. The surveys do record information on additions to household capital since the start of the HRS therefore this information can be combined with the information on the household's capital base to gain an estimate of household capital resources in 1988 and 1993.

Also included in the estimations are three dummy variables representing three of the four provinces in the survey areas (Zhejiang, Jilin, and Jiangxi are included; Henan is omitted) and three dummy variables reflecting important aspects of land-tenure institutions in China. The three land-tenure measures included in the survey are variables representing land-tenure security, land fragmentation and farm size. The means of key characteristic for each of the sample groups is included in Table 3.1. These three aspects of land tenure were chosen for inclusion based on their importance in current research and policy discussions regarding land-tenure issues in China. This paper marks the first time that the variables for land-tenure security and land fragmentation have been included in a profit function analysis.

The variable for land-tenure security measures whether or not a village has experienced an administrative reallocation of land since the introduction of the HRS. Several authors have shown that such reallocations are the primary determinant of current land-tenure security levels for village households in China (Turner et al 1998; Carter and Yao 1998; Li 1998). Households in villages that previously reallocated land have a greater expectation that their land will be reallocated again in the future, thereby leading to lower levels of land-tenure security.

Households in villages with insecure land tenure would be expected to have both lower technical and price efficiency than households in areas with secure tenure. Price efficiency would be impacted because households in areas with insecure tenure would be expected to use less than the profit-maximizing amount of long-term inputs. The impact on short-term inputs can not be determined a priori, and depends on substitution and complementary effects between short- and long-term inputs. Lower technical efficiency would result due to accumulated under investments in land resources by households in areas with insecure tenure. Given an identical set of current year inputs, households in areas with insecure tenure would be expected to exhibit lower returns than households in areas with secure tenure due to lower land productivity.

The second variable measuring an aspect of land tenure is the variable measuring land fragmentation. Several researchers and government officials have identified land fragmentation is a serious concern in Chinese agriculture (He 1995; Huang 1995; Cheng and Tsang 1995). Agricultural land held by farm households is typically divided into a number of small plots that are scattered around the village areas. The small and scattered nature of these plots is thought to reduce agricultural productivity by preventing the application of scale technologies, and by leading to a great deal of wasted time for farm households as they move from plot to plot (Cheng and Tsang 1995; Huang 1995; Brandt 1987).

The variable used in this study is a dummy variable reflecting the average size of household land plots. Those households with land plots smaller than the average size for the sample are classified as having fragmented land plots, while those households with land plot sizes larger than the average are classified as being non-fragmented. Households with fragmented land would be expected to have lower technical efficiency than households without fragmented land if land fragmentation

does reduce agricultural productivity. If two households had equal resources, the household with land fragmentation might be expected to have lower production due to wasted resources and inability to harness scale technologies. Price efficiency in this case might not be as strongly differentiated, except to the degree that households are unable to use certain inputs due to the fragmented nature of their land holdings.

The final variable measuring an aspect of land tenure used in this survey is the variable comparing small versus large farms. As in several previous surveys, small farms are those households farming land areas that are smaller than the average for all households in the sample, while large farms are those households with greater than the sample average of land. While a wide body of literature exists indicating that in most developing countries small farms are more productive than large farms¹², in China most researchers have found large farms to be more efficient than small farms. The higher technical efficiency found for small farms in most developing countries is thought to be the result of the direct supervisory and leadership role of the owner-manager of the small farm (Yotopoulos and Lau 1973). However, researchers have posited that the extremely small size of farm plots in China leads to inefficiencies in input use and other problems that result in lower technical and price efficiency for small farmers. Therefore, based on previous research in China, large farms might be expected to display greater technical and price efficiency than small farms.

In summary, economic theory and previous research leads to several hypotheses for how land tenure variables might impact agricultural production. Based on the discussion presented in the section above and in Chapter 2 of this dissertation, several hypotheses can be developed and tested in the empirical application to follow.

¹² See Berry and Cline (1979) for a survey of this literature. One of the key studies in this field was Lau and Yotopoulos's study of Indian agriculture described earlier (Lau and Yotopoulos 1971). With regard to the contrary results reported for China, see for example Brandt (1987) or Wang et al (1996).

First, decreased security of land tenure, as measured by the presence of administrative land reallocations, would be expected to reduce price and technical efficiency in agricultural production. Second, the existence of land fragmentation as measured by small average household plot sizes is expected to result in lower technical and price efficiency. Finally, large farms in China might be expected to exhibit higher technical and price efficiency than small farms. The following section presents the results from estimations of the model presented in this section, and describes the results of tests performed to examine the hypotheses developed here.

3.4.3 COBB-DOUGLAS RESTRICTED PROFIT FUNCTION ESTIMATION RESULTS

The general system of equations estimated is described in equations 3.22 to 3.25. The analysis includes several specifications to test for the influence of different land-tenure practices on agricultural productivity. All estimations include both a restricted profit function and three factor-share equations, one for each of the variable inputs in the model. Throughout this analysis, an individual household is assumed to be a price taker with respect to its variable inputs and output, and the quantities of its land, labor and capital resources are assumed to be fixed in the short-run. These conditions are reasonably assumed in the case of China as individual households are too small to affect input and output prices, and markets for land and agricultural labor are extremely limited. A similar specification was used by Wang et al (1996), the only other paper to apply duality theory to post-1978 Chinese agriculture.

As outlined by Yotopoulos and Lau (1979), output and the amounts of the three variable inputs are jointly determined, while the prices and amounts of the fixed factors are pre-determined. Therefore, the left-hand side variables described in equations 3.22-3.25 are jointly determined, while the right-hand side variables are pre-

determined. Given these conditions and the set of equations to be estimated, the most efficient estimation can be obtained by using Zellner's seemingly unrelated regression (SUR) technique¹³. Equation by equation estimation using ordinary least squares (OLS) in this case is consistent, but not efficient. Asymptotically efficient estimation can be achieved by estimating the system of equations outlined in 3.22-3.25 jointly using a Zellner SUR model.

All previous studies applying the Lau and Yotopoulos restricted profit-function approach report both OLS results and the Zellner SUR results. This study follows their lead by reporting both results for comparison, but concentrates on the Zellner efficient results for statistical tests and discussion. Both sets of results are reported in a single table for separate regressions using the 1989 and the 1993 data. Tests of the hypotheses of interest can be conducted using F-ratio tests. The results of these tests, both the F-statistic and the probability of acceptance of the null-hypothesis, are reported in separate tables for each regression procedure.

ESTIMATES OF THE GENERAL COBB-DOUGLAS RESTRICTED PROFIT FUNCTION

The first estimation that is considered is the most general system to be studied. The variables in the estimating equations in this case include: the normalized prices of the three variable inputs, fertilizer, organic fertilizer and machine and animal input hours; the amounts of the three fixed inputs, sown land, household labor and household capital; dummy variables for the three land-tenure institutions considered, land-tenure security, land fragmentation and farm size; and regional dummy variables for three of the four provinces included in the data set, Zhejiang, Jiangxi and Jilin. (Henan is omitted to avoid singularity). In this specification, price efficiency is assumed to be equal across all households, a restriction that is loosened in later

¹³ See Zellner (1962) for a statistical description of the methodology.

regressions. An overall test of price efficiency is possible in the current regression through the test of profit maximization, and tests of economic efficiency are performed. The inclusion of the full set of dummy variables for land-tenure measures permits an exploration of interactions between the various land-tenure categories that is not possible in the later regressions that focus on only one land-tenure category at a time.

For this first system, estimates of the coefficients and absolute values of the relevant t-statistics from the regression are presented in Table 3.2. The results of the hypothesis tests are reported in Table 3.3. Results for this and all subsequent regressions are reported separately for 1988 and 1993. A Chow break-point test was performed to test the suitability of combining the 1988 and 1993 data sets into one pooled sample. As reported in Table 3.3, the hypothesis of stability in the parameters of the profit function was rejected. The results in Table 3.2 indicate that the Zellner SUR model generally provides more robust parameter estimates than the equation by equation OLS procedure. In both 1988 and 1993, almost all of the coefficients on the included variables are statistically significant in both specifications, although the results are stronger for the Zellner procedure. Therefore the discussion that follows focuses on the last two columns of Table 3.2, the results for the Zellner estimation procedure.

While the reported results are generally significant, several of the parameters have unexpected signs. The most significant deviations from expected results occur with regard to the parameter estimates on the normalized prices of the variable inputs. In each year, only one of the three variable inputs has the expected negative sign. For example, in 1988 only the coefficient associated with the fertilizer price variable is negative, while the coefficients on the other two variable inputs, organic fertilizer and machine and animal inputs, are positive. While only the coefficient on the organic

fertilizer price variable is highly statistically significant, the other two coefficients are both significant at the 15 percent level, indicating that the inappropriate signs are unlikely to be due only to coefficient insignificance. In 1993, two of the coefficients on the input price variables again have positive signs and one is negative. However, in this case the coefficient on machine and animal inputs that is negative and the coefficient on fertilizer is positive, an opposite result from the previous observation. All the coefficients in 1993 are statistically significant at the 5 percent confidence level.

A positive sign on the coefficients of the variable-input prices would appear to violate the assumption of a downward-sloping demand curve for the inputs. The result implies that restricted profits increase as the prices of these inputs increase, the opposite effect from what is typically assumed. This result may be generated by errors in the collection or aggregation of the data, a lack of market development or restrictions on the operation of markets in China. For example, certain prices, such as that of organic fertilizer, might not be accurate in the survey due to the high degree of self-provision of this input. In addition, as discussed by Putterman (1993), the assumption of well-functioning markets in purchased inputs in Chinese agriculture may also not be valid because some inputs might not be freely available at the reported prices. Restrictions by officials or imperfections in market structures such as transportation and distribution might prevent the free operation of supply, demand and prices in the market. While every effort was made to obtain accurate market prices of the inputs, the lack of direct information on prices and market operation might lead to the unexpected positive coefficients on the variable inputs.

It might be noted, however, that the observation of positive coefficients on variable-input price parameters is not at all uncommon in previous papers using the restricted profit-function approach. For example, most of the studies in the Yotopoulos

and Lau (1979) volume report similar positive coefficients in their estimation of an unrestricted Zellner SUR model. The paper on Taiwan from that volume reports positive coefficients for two of the three variable input price parameters in 1967. Other papers in the volume also exhibit positive coefficients on the variable input price parameters in their unrestricted estimations, including the papers from Turkey, Thailand and Malaysia. Researchers outside of agriculture have also found positive coefficients on several of the variable input price parameters (Atkinson and Halvorsen 1980; Atkinson and Halvorsen 1984).

One key difference between the current study and the papers reported in the Yotopoulos and Lau volume is that the results reported in the earlier volume represent restricted regression systems, while all regressions in this study are unrestricted. The restrictions in their study are imposed based on their non-rejection of the hypothesis of profit maximization due to poor coefficient estimates. In the current study, as will be discussed shortly, the hypothesis of profit maximization is rejected, in part because the coefficients on the relevant variables are highly significant and display small standard errors. Therefore, the results reported here, while seemingly violating economic assumptions, may in fact be of a more robust nature than the results reported in the Yotopoulos and Lau supervised studies.

For this study, the test results for a test of profit maximization are reported in Table 3.3. As can be seen from the table, the hypothesis of profit maximization is strongly rejected for both years. Households in the areas studied in China do not appear to efficiently use variable inputs at observed prices. This result matches that found by Wang et al (1996) for a similar sample of Chinese agricultural households. It also matches the result found by Elliot Parker for the Chinese construction industry (Parker 1992). Similar results were found for agricultural households in other developing countries (Ali et al 1994; Kumbhakar and Bhattacharyya 1992). It differs,

however, from the results found by other studies using the Lau and Yotopoulos profit function approach, including those discussed earlier that focus on pre-Revolutionary Chinese agriculture (Yotopoulos and Lau 1973; Yotopoulos and Lau eds. 1979; Troster 1978; Brandt 1987).

Because some aspects of agricultural production are still regulated in China, and markets for agricultural inputs and output are not fully developed, a rejection of profit maximizing behavior for Chinese agricultural households is not unexpected. Likewise, a finding of increasing profits with regard to some of the variable input prices is also not totally unexpected, in that it may be true that some variable inputs may not always be available at observed prices. To better understand the actions of households when profit maximization is not observed, researchers have attempted to uncover estimates of the shadow prices that households appear to be following in their decisions on the use of variable inputs.

The Lau and Yotopoulos methodology allows an examination of shadow-price parameters for the variable inputs. None of the papers written or overseen by Lau and Yotopoulos examine the case of shadow-price parameters, because if the hypothesis of profit maximization is accepted, then the shadow-price parameters are unitary and drop out of the analysis. However, if households are not maximizing profits based on observed prices, then the implied shadow-price parameters can be obtained from the regression results. For this regression, the shadow-price parameter for each of the variable inputs is reported in Table 3.3.

A shadow-price parameter of less than one indicates that the shadow price of an input is less than its observed price, while a shadow-price parameter of more than one indicates that the observed price is less than the shadow price. The negative signs are generated due to the positive signs on the parameters for several of the variable

inputs in the regression in Table 3.2. The negative signs result from the finding that profits increase as the prices of these variable inputs increase. Based on this analysis, all of the variable inputs except machine and animal inputs in 1993 have shadow prices below their observed prices. The true cost to households of using these inputs is well below the market-reported price. As discussed above, the discrepancy between shadow prices and market prices may be due to problems in generating the reported prices or due to interventions and imperfections in markets for agricultural inputs and output.

Two additional tests that can be conducted using the regression results, including an examination of relative economic efficiency between groups with varying land-tenure institutions and a test of constant returns to scale. In the Lao and Yotopoulos framework, tests of relative economic efficiency can be conducted by examining the significance of the coefficients on dummy variables representing selected groups. For example, in the current regression dummy variables for three tenure groups are included: households in areas with poor tenure security; households with non-fragmented land; and households with large farms. If these land tenure factors have a significant impact on economic efficiency, then the coefficient on the dummy variable should be significant. A negative coefficient indicates that the group has lower economic efficiency than the default group, and vice versa for a positive coefficient. The regional dummy variables can also be interpreted in a similar manner.

Tests of significance for the dummy variables in the current regression are tests for differences in economic efficiency among the highlighted groups. As all three groups are included in the regression, they consider the joint influence of the three land-tenure measures. The significance of these variables can be determined using the information presented in Table 3.2. It can be seen that for 1988, based on t-tests of significance, households in villages with land readjustments have significantly lower

economic efficiency, while households with large, contiguous parcels of land have significantly higher economic efficiency. Farm size alone does not have a significant impact on household economic efficiency. In 1993, similar results are found for land with poor tenure security and large farm size, but in this regression land fragmentation has a positive influence on economic efficiency, although the variable is not significant. Other than this last coefficient's sign, the results are as expected, and tend to confirm the hypotheses that land fragmentation and poor land-tenure security can act to reduce farm households' economic efficiency.

The results of this initial regression are generally in line with several previous studies of Chinese agriculture as outlined in the earlier literature review. Poor land-tenure security may reduce economic efficiency through lower levels of long-term land improvements as found by Rozelle et al (1998) and Carter and Yao (1998). Land fragmentation may reduce productivity due to wasted time spent traveling between plots or an inability to apply certain technologies as found by Brandt (1987) and Fleischer and Liu (1992). The opposite sign on the fragmentation variable for 1993 is not easily explained, but may be due to cropping patterns, weather and risk. Studies have shown that land fragmentation can actually be beneficial in certain circumstances because they allow farmers to manage risk, overcome labor shortages and match crops to soil types and climates (Blarel et al 1992).

The insignificant results for farm size are different from the significant results found by Brandt (1987) and Wang et al (1996) for China. These studies found large farms in both pre-Revolutionary and contemporary China are more efficient than small farms. A later specification that allows small and large farms to differ in price efficiency will explore the relative efficiency of the two types of farms more thoroughly. Overall, the results reported for the coefficients on the land-tenure variables are generally in line with expectations, and offer several interesting insights

that are explored more thoroughly in later estimations focusing on each land tenure variable individually.

The regional dummy variables that are included all have negative signs and are significant in both 1988 and 1993. This is an indication that farmers in Henan, the omitted provincial area in the regression, have the highest economic efficiency in the sample. Farmers in Zhejiang in 1988 and Jiangxi in 1993 appear to have the lowest economic efficiency. These results may be due to the fact that households in Henan rely almost exclusively on crop farming for their livelihoods, while households in other areas, particularly Zhejiang, get some of their income from non-farm work opportunities. Wang et al (1996) found off-farm work to be a factor contributing to lower economic efficiency among Chinese farm households.

A final test that can be conducted using the results reported in Table 3.2 is a test of returns to scale. This test consists of an F-test to determine whether the value of the coefficients on the fixed factors of production sum to one. The test statistics are reported in Table 3.3. This test rejects the hypothesis of constant returns to scale for 1988, but accepts it in 1993. For 1988 the sum of the coefficients on the fixed factors is 1.16, an indication of increasing returns to scale. This finding is similar to that of Feder et al (1992) who also used a data set from China gathered in 1988. The decline in returns to scale over time may be an indication of a greater ability of small farmers to adapt technology and knowledge that was previously only available to large farmers.

The coefficients on the fixed factors generally have the expected signs, although the coefficient for labor in 1988 is negative (but is not significant) and the coefficient for household capital is negative in 1993. These findings may be due to misspecification in the variables. Lau and Yotopoulos (1971) observed a similar

result. In general, the production impact of both capital and labor are small in comparison to land due to the relatively large labor force for the small amount of available land and household capital. This finding is similar to that found in most other production studies of Chinese agriculture (Putterman 1993; Putterman and Chiacu 1994; Fleisher and Liu 1992; Feder et al 1992).

ECONOMETRIC ISSUES

Several additional econometric issues must be noted when considering the strength of the results from the regressions in this dissertation. First, as was extensively discussed above, the results reported indicate that the restricted profit function is not well behaved in certain aspects with regard to both the prices of the variable inputs and the amounts of the fixed inputs. Profit function estimation typically assumes a well-behaved profit function exists. The contrary parameter estimates achieved in this paper weaken, but not invalidate, findings such as the land tenure results reported.

A second important issue to be considered is the problem of omitted variable bias. The empirical specifications used in this chapter and Chapter 4 of this dissertation omit numerous household and village characteristics that may impact agricultural production. For example, important variables such as farm soil quality, rainfall and weather phenomena that may be household or village specific, household managerial ability and other unobserved characteristics may bias the reported results. In addition, certain households may receive preferential access to high quality land, inputs or output markets due to connections with government officials or other unobserved characteristics.

An example of the bias omitted variables can create in reported results for agricultural production studies is outlined by Angus Deaton (1993). This paper reports

that many of the studies testing for the difference in agricultural productivity between large and small farms fail to take differences in land quality between the two types of farms into account in their estimation techniques. As was discussed earlier, most studies find that small farms are more efficient than large farms. However, researchers have noted that large farms are often large because they include areas with marginal land quality. If land quality measures are not included in the empirical estimations, the results are biased toward a finding that small farms are more efficient because they produce more per acre of land. However, if land quality indicators are included in the regressions, the difference in economic efficiency between the two types of households disappears. The true difference in production between the two types of farms is due to differences in land quality not differences in economic efficiency. Similar biases might be present with regard to the use of inputs such as fertilizer. Households with greater managerial ability or better quality land, both unobserved qualities, gain higher returns from their use of both variable and fixed inputs.

In the current study, the direction of bias introduced by possible omitted variables may not conform to those from studies of other developing countries. For example, in contrast to studies from many developing countries, most studies of Chinese agriculture find that large farms have greater economic efficiency than small farms. This may be due to the ability to use scale technologies on large farms, or other factors that may influence the farm size/productivity relationship. It may also be true that large farms have higher quality of land because they are located in areas with relatively flat, open parcels of land that are suitable for use of mechanized farm equipment or that have extensive irrigation facilities. There is evidence that the Chinese government has promoted the development of large farms by giving them preferential access to credit, machinery and agricultural inputs such as fertilizer (Huang 1995). The government views such farms as more “modern” and thus

promotes their development. While this study did not find clear evidence of large or small farm superiority, a bias may be present in this case toward large farms.

A similar result may be driving the findings for land fragmentation. Several studies in addition to the current one have found that land fragmentation in China reduces agricultural productivity (Fleischer and Liu 1992; Brandt 1987). However none of these studies control for a possible connection between land quality and land fragmentation. It may be expected that mountainous areas or other areas with poor land quality might also display more fragmented land. Thus a finding of lower productivity for fragmented land may only be related to land quality differences, not production problems related to the fragmentation of household land holdings.

One technique that has been used to correct for omitted variable bias in certain cases is the use of fixed-effect regression techniques. If at least a two a two-period panel exists, the observations for a single household can be differenced across time periods to remove the effects of unobserved household specific characteristics such as managerial ability or soil quality from the estimation. However, as outlined by Deaton (1993) there is a cost to using such procedures. Problems such as a reduction in the number of available observations, the requirement that the omitted variable take the form of an additive fixed effect and a reduction in precision due to reduced variability in variables that are correlated over time limit the applicability of fixed effects regressions.

For the restricted profit function estimates considered in this dissertation, a fixed-effect regression was attempted using the data available for certain households over both time periods. However, several problems prevented the successful adoption of this technique in the current study. First, only a subset of households are matched across the two time periods, and thus the sample size in the fixed-effect regression is

substantially smaller than in the single period regressions. Second, because the land tenure variables of interest do not typically change over time (i.e. a large farm in 1988 remains a large farm in 1993), little variation exists in the differenced form of these variables.

Only households that change land tenure status between the two time periods are identified in the fixed-effect equation specification, thus it is almost impossible to achieve significant parameters on the land tenure measures. Finally, there is some question of stability between the data sets in the two time periods that might introduce noise into the estimating procedure. The gap of 5 years between the gathering of the two data sets, the problem that the questions in the two data sets do not identically correspond, and the fact that only certain households are matched between the two time periods, all introduce possible noise into a regression combining both data sets. As was reported in Table 3.3, Chow tests of the stability of the parameters between the two time periods reject pooling of the data. For these reasons, the fixed-effect regression results were not considered robust enough to report in this paper. In the future, the problem of omitted variable bias might be tackled by the gathering of more information on household and farm characteristics such as land quality, education and other factors that influence household production.

An additional econometric issue that should be noted is related to the possible endogeneity of the variables in the empirical regressions. Questions are often raised about the endogeneity of land-tenure rights measures, investment and agricultural production. For example, studies of land-tenure and agricultural investment in Africa find it impossible to distinguish whether investments farmers make in land are increased due to greater tenure security, or whether farmers increase investments in an attempt to enhance their tenure security. An example of the latter case is when farmers assert private ownership of a plot of land by building a barn on the land (Besley 1995).

In the current study, it might be hard to distinguish issues such as whether land reallocations reduce agricultural productivity, or whether land reallocations occur *because* agricultural productivity is low. Likewise it may be the case that land is fragmented or farm size varies because of low productivity. Unfortunately, in empirical applications it is often impossible to determine the direction of causality in the regression. Additional data, field observations and new techniques may help unravel the mystery, but it is typically impossible to determine with certainty that the direction of causality is robust. In the current case, fairly strong evidence from field studies and previous empirical work does exist that farmers in China do reduce their investments and change their production behavior due to poor tenure security, land fragmentation and small farm size. Therefore, while the issue is important to keep in mind, the results achieved can not be dismissed only on the grounds of possible endogeneity in the regressions.

CONCLUSION

In summary, the results displayed in Tables 3.2 and 3.3 offer some insight into production efficiency in Chinese agriculture. Almost all of the coefficients on the variables tested are significant. The positive signs on the variable inputs and rejection of profit maximization are contrary to the final findings of Lau and Yotopoulos, but are not unprecedented, and in fact may be an indication of improved rather than poor results. Perhaps the most significant finding is that of differing economic efficiency among land tenure groups. This is the first time that land-tenure institutions of this type were included in a profit-function analysis. In order to gain a better understanding of how land-tenure institutions may be affecting agricultural productivity, separate regressions for each of the three land-tenure institutions are examined in the sub-sections below. These regressions allow an examination of

economic, technical and price efficiency for groups of farm households, and explorations of other factors related to farm production.

3.4.4 ESTIMATION AND HYPOTHESES TESTS OF REGRESSIONS FOR LAND-TENURE GROUPS

The primary focus of the seminal work by Lau and Yotopoulos utilizing the restricted profit function to study economic efficiency was a comparison between two groups of farmers, namely large farms and small farms in India. The authors use dummy variables to separate households into groups, and then test relative economic, technical and price efficiency between the two groups of farmers and absolute efficiency for each group of farmers. This paper provides a similar test between groups of farmers, but instead of only testing between large and small farms, it also includes two other land tenure groupings, farmers with secure land tenure versus those without secure tenure and farmers with fragmented land versus those without fragmented land. For each of these three land-tenure institutions separate regression procedures and sets of hypothesis tests are conducted.

The regressions tested differ from the equations outlined in 3.22-3.25 in that only one of the three land tenure dummy variables is included in the profit function of each regression, while the factor-share equations include dummy variables for each side of the land tenure groups in focus, for example a dummy variable for small farms and one for large farms. The final estimating equations take the form:

$$(3.28) \quad \ln \Pi^* = \ln A^{i*} + \delta_x^* D_x + \alpha_i^* \ln q_i + \beta_j^* \ln Z_j + \sum_{k=3}^6 \delta_k D_k$$

$i = F, O, M; j = T, L, K$

$$(3.29) \quad \frac{-q_i X_i}{\Pi^*} = \alpha_i^{*2} D_x + \alpha_i^{*1} D_y; i = F, O, M$$

In these equations, D_x is the dummy variable for households belonging to one side of the land tenure issue being studied (villages with an administrative land adjustment; large land parcel size; and large farms), while D_y is the dummy variable for the opposite group of households (villages without adjustment; small parcel size; and small farms).

As outlined in the methodological section, six hypothesis tests can be constructed utilizing the results from equations such as those described in 3.28 and 3.29. These tests include:

- 1) Equal Relative Economic Efficiency.

$$H_0: \delta_x^* = 0$$

This test is the same as the one performed in the previous regression, a test of the coefficient on the land-tenure dummy variable in the profit function. If it is significantly greater or less than zero, the group of households in question has higher or lower economic efficiency than the opposite group.

- 2) Equal Relative Price Efficiency.

$$H_0: \alpha_i^{*T} = \alpha_i^{*D}; i = F, O, M$$

This is a test of the coefficients on the variable-input prices in the factor-share equations. If they are statistically the same, then the two groups of households have equal abilities to profit maximize, even if absolute profit maximization is achieved.

- 3) Equal Relative Technical *and* Price Efficiency

$$H_0: \delta_T^* = 0 \text{ and } \alpha_i^{*T} = \alpha_i^{*D}; i = F, O, M$$

Equal relative technical and price efficiency depends on a test of the joint hypotheses tested individually in 1) and 2). Rejection of 1) or 2) typically leads to a rejection of this hypothesis.

4) and 5) Absolute Price Efficiency for Each Group of Households

$$H_0: \alpha_i^{*T} = \alpha_i^*; i = F, O, M$$

$$H_0: \alpha_i^{*D} = \alpha_i^*; i = F, O, M$$

These two tests look at the absolute price efficiency of each group of households separately, comparing the coefficients on the variable-input prices from the profit function with those from the factor-share equations.

6) Constant Returns to Scale

$$H_0: \sum \beta_j^* = 1; j = T, L, K$$

The test for constant returns to scale has a null hypothesis that the coefficients on the fixed factors of production sum to one.

REGRESSION RESULTS FOR LAND-TENURE GROUPS

The results from the three separate regressions for land-tenure security, land fragmentation and farm size are presented in Tables 3.4, 3.6 and 3.8, while the corresponding hypothesis tests are presented in Tables 3.5, 3.7 and 3.9. The results are discussed in turn for each regression and hypothesis test. Because the coefficients on variables other than those directly related to the land tenure issue of focus do not

change dramatically from the initial regression, they are generally omitted from the discussion below. A similar condition holds for the test of constant returns to scale.

In addition, while the results are not reported here, alternative specifications for each regression were attempted to test for interactions between the land-tenure variables. In all three cases, the addition of one or both of the other land-tenure variables did not alter the significance of the results reported. This indicates that there exist only weak interaction effects between the three land-tenure measures. The significance of each land-tenure measure is independent of the other measures. This differs, for example, from the results found by Trosper (1978). He found significantly different results with regard to relative economic efficiency results for Indian and Anglo ranchers after including a measure of land tenure (owned versus rented land). In the current regressions, results and hypothesis tests are not affected by the inclusion of land-tenure variables beyond the two groupings that are the focus of each analysis.

HOUSEHOLDS WITH ADMINISTRATIVE LAND READJUSTMENTS VERSUS HOUSEHOLDS WITHOUT ADMINISTRATIVE LAND READJUSTMENTS

First, the regression results for villages that have readjusted land versus those households in villages that have not readjusted land. The regression results are presented in Table 3.4, while the hypothesis tests are presented in Table 3.5. The first hypothesis to be tested is the hypothesis of equal economic efficiency between the two groups. This consists of a test of the significance of the coefficient on the dummy variable in the profit function regression. For both 1988 and 1993, the coefficient on the dummy variable for households in villages that have reallocated land is negative, but not significant, although it is nearly so in 1993. Based on these results, the hypothesis that households in areas that have reallocated land have equal economic efficiency to households in areas that have not reallocated land can not be rejected.

This finding differs from that obtained in the general regression where the coefficient on the dummy variable for land reallocations was significantly negative in both years.

The current equation differs from the earlier equation in that price efficiency is allowed to vary between the two groups in the current framework, while it is assumed to be equal in the previous set up. The second and third tests that are described in Table 3.5 indicate that in 1988 households in the two groups differed significantly in their ability to achieve price efficiency, economic efficiency and joint technical and price efficiency. These tests indicate that the differences in economic efficiency seen in the earlier general regression (the results displayed in Table 3.2) can be explained primarily by differences in price efficiency between the two groups of households. In 1993, however, no significant difference in price or economic efficiency was found between the two groups of households. This result indicates that price efficiency differences between the two groups of households were not primarily responsible for the differences in economic efficiency found in the general regression reported in Table 3.2. Neither group achieved absolute price efficiency.

The difference in price efficiency between the two time periods is an indication that the two groups of farmers had substantially different use patterns for the variable inputs in 1988, but not in 1993. By examining the factor-share equations, it can be seen that in 1988 those areas with land adjustments used more chemical fertilizer and less machine and animal inputs as a share of their net profits, but the two groups used a similar amount of organic fertilizers. Based on the discussions presented earlier regarding land-tenure security, it might be expected that areas with land adjustments might use less of the long-term input (organic fertilizer) and more of the short-term input (chemical fertilizer) than areas without land adjustments.

The finding that organic fertilizer use is similar, but chemical fertilizer use is higher in areas with land adjustment offers a clue into why previous studies found only a small impact on overall productivity from poor land-tenure security. It may be that farmers in areas with land readjustments increase their use of short-term inputs such as chemical fertilizers or for other reasons that are uncontrolled in the regression (such as crop type) they use more chemical fertilizers than the regions that do not reallocate land. The higher use of short-term inputs may provide a substitute for longer-term inputs or land improvements and allow farmers to overcome any productivity dampening effects created by poor land-tenure security. This substitution effect seems to have diminished by 1993, based on the equality in the input use shares and the near significant finding for differences in economic efficiency. The differences in economic efficiency may be related to the accumulated effects of previous under-use of long-term inputs.

HOUSEHOLDS WITH LARGE LAND PARCELS VERSUS HOUSEHOLDS WITH SMALL LAND PARCELS

The second system to be considered looks at farms with large land parcels versus farms with small land parcels. The regression results and hypothesis tests are displayed in Tables 3.6 and 3.7. This system provides a test of the impact of land fragmentation on production efficiency. The test for economic efficiency in this case indicates that farms with large parcels, those without land fragmentation, are more economically efficient in 1988, but the two groups have equal economic efficiency in 1993. Equal relative price efficiency is rejected in both time periods, as is equal relative technical and price efficiency and absolute price efficiency for both groups.

These results indicate that the two groups of households continued to have fundamentally different use patterns for the variable inputs in question across the two time periods, but differences in economic efficiency did not persist from 1988 to 1993.

In both time periods, farms with fragmented land bought more organic fertilizer and fertilizer compared to their profits than non-fragmented farms, but less machine and animal services. Such differences in factor use may be responsible for part of the apparent connection between parcel and farm size, land readjustments and economic efficiency.

LARGE FARMS VERSUS SMALL FARMS

The final set of results looks at small versus large farms. The results and hypothesis tests are displayed in Tables 3.8 and 3.9. The first test for equal relative economic efficiency is rejected for 1988, but accepting for 1993. In 1988, large farms are significantly more economically efficient than small farms, but this difference evaporates by 1993. The second test strongly rejects equal price efficiency in 1988 and weakly rejects it for 1993 (at the .10 level but not the .05 level). The same result is true for equal relative technical and price efficiency in the two time periods, while as in all previous regressions absolute price efficiency is rejected for both groups and time periods.

These results are somewhat different from those in the regression with all three land-tenure variables where farm size seemed to have no effect on economic efficiency, but match the findings of Brandt (1987) and Wang et al (1996). While most research worldwide has found that small farms are more efficient than large farms, Chinese farms may be too small to gain an advantage through improved direct supervision, the primary reason small farms are thought to be more efficient (Feder et al 1992). The extremely small farm size in China may lead to inefficiencies in small farms that are not found in other countries, thus reversing the usual paradigm. The increasing returns to scale in 1988 is evidence of this effect. The results of the factor-share equations show that small farms used significantly higher shares of machine and

animal inputs and organic fertilizers in 1988 compared to their profits, but these differences narrowed by 1993.

SECTION 3.5 CONCLUSION

To summarize the regression results, equal relative economic efficiency is rejected for situations of land fragmentation and due to farm size in 1988, but can not be rejected for areas with different land-tenure security in 1988 and all areas in 1993. These results might be expected in that less efficient economic institutions might be expected to reform over time to become more efficient. For example, if large farms or less fragmented land were much more efficient than small farms or fragmented land, then one might expect small or fragmented farms to adopt practices to overcome such differences or consolidate land. Likewise differences in relative price efficiency seemed to ease over time, and factor shares were much more similar among groups in 1993 than in 1988. Statistically, however, differences in price efficiency did persist among farmers with fragmented land and between small and large farms. Such differences may be due to difficulties small farms may have in purchasing inputs, or difficulties in using some inputs on very small farms or fragmented land.

The results presented above generally hold to a priori expectations, although certain results, such as the rejection of profit maximization in all cases, vary from previous studies using the same methodology. The results do suffer, however, from certain econometric issues as discussed earlier. Overall, the findings indicate that land-tenure institutions do impact agricultural productivity, and those areas with poor land-tenure security or fragmented land generally are shown to have lower economic efficiency. Therefore, it may be possible to increase agricultural production in China by reforming the land-tenure system to provide farmers with greater tenure security and consolidated land plots. These objectives might be accomplished under the

Household Responsibility System by offering farmers longer-term contracts for their agricultural land holdings, and through government support or non-interference in markets for agricultural land. Through these efforts, agricultural production might be increased to meet the growing demand for food as the country's population and affluence increase. These achievements might be accomplished without diverting additional scarce resources to the agricultural sector.

TABLE 3.1

MEANS OF VARIABLES MEASURING PROFITS AND FIXED INPUTS

	Profits (Yuan) 1988	Profits (Yuan) 1993	Land (mu) 1988	Land (mu) 1993	Labor (Persons) 1988	Labor (Persons) 1993	Labor (Hours) 1988	Labor (Hours) 1993	Household Capital (Yuan) 1988	Household Capital (Yuan) 1993
Whole Sample	2191.0	3949.9	18.2	17.7	3.1	3.4	2567.8	2481.2	5712.8	6057.7
Households with Land Adjustment	2973.8	4224.1	21.3	18.8	3.3	3.4	4202.8	2851.4	5916.7	6489.5
Households without Land Adjustments	1851.8	3296.6	16.1	15.1	3.0	3.2	1864.6	1609.5	5633.3	5433.0
Households with Large Parcels	3095.1	3715.6	22.4	19.3	3.2	3.3	2684.3	2479.1	5649.0	7175.8
Households with Small Parcels	1291.4	4186.7	14.2	16.1	3.0	3.4	2466.1	2483.3	4416.8	5384.7
Large Farms	3783.9	5858.4	29.2	28.0	3.23	3.6	3630.0	3553.4	5678.9	5804.1
Small Farms	598.0	1991.1	7.4	7.3	2.9	3.2	1510.9	1389.5	5766.3	6484.2

TABLE 3.2
REGRESSION RESULTS - COBB-DOUGLAS PROFIT FUNCTION - GENERAL

	Parameter	OLS 1988	OLS 1993	Zellner SUR 1988	Zellner SUR 1993
Profit Function					
Variable and Fixed Inputs					
	Constant	2.03 (1.97)	4.86 ¹ (12.64)	3.91 ¹ (6.29)	5.31 ¹ (18.78)
	Fertilizer	-1.84 ¹ (3.96)	.41 ¹ (2.81)	-.41 (1.46)	.57 ¹ (5.25)
	Organic Fertilizer	1.05 ¹ (3.36)	1.31 ¹ (8.98)	.46 ¹ (2.44)	.98 ¹ (9.21)
	Machine and Animal Inputs	1.16 ¹ (3.15)	-.95 ¹ (7.12)	.35 (1.56)	-.66 ¹ (6.76)
	Sown Land	1.27 ¹ (22.48)	.92 ¹ (23.99)	1.17 ¹ (34.50)	.90 ¹ (31.66)
	Household Labor	-.02 (.43)	.09 ² (1.89)	-.02 (.53)	.10 ¹ (3.11)
	Household Capital	.02 ² (1.8)	.05 ¹ (2.94)	.01 ² (1.7)	-.04 ¹ (3.27)
Land Tenure and Regional Dummy Variables					
	Administrative Land Readjustment (1=yes)	-.15 ¹ (2.20)	-.09 (1.80)	-.12 ¹ (2.87)	-.09 ¹ (2.41)
	Land Fragmentation (1=no)	.19 ¹ (4.00)	.06 (1.31)	.11 ¹ (4.07)	-.06 ¹ (1.66)
	Farm Size (1=large)	.15 ² (1.92)	-.04 (.58)	-.03 (.57)	-.02 (.54)
	Zhejiang	-2.42 ¹ (8.15)	-.47 ¹ (3.00)	-1.41 ¹ (7.89)	-.54 ¹ (4.71)
	Jiangxi	-1.99 ¹ (9.17)	-3.58 ¹ (8.91)	-.69 ¹ (10.60)	-2.88 ¹ (9.77)
	Jilin	-.03 (.19)	-.23 ¹ (2.15)	-.22 ¹ (2.14)	-.49 ¹ (6.07)
Factor Demand Functions					
	Fertilizer	-.62 ¹ (9.03)	-.25 ¹ (26.69)	-.62 ¹ (9.04)	-.25 ¹ (26.71)
	Organic Fertilizer	-.14 ¹ (9.02)	-.07 ¹ (12.89)	-.14 ¹ (9.02)	-.07 ¹ (12.90)
	Machine and Animal Inputs	-.62 ¹ (11.84)	-.31 ¹ (12.24)	-.62 ¹ (11.85)	-.31 ¹ (12.24)

*Absolute Values of t-statistics are included in parentheses. 1 = Significant at the .05 significance level; 2 = Significant at the .10 significance level.

TABLE 3.3
HYPOTHESIS TEST RESULTS - COBB-DOUGLAS PROFIT FUNCTION - GENERAL

<u>Test</u>	<u>Parameters</u>	<u>Chi Squared</u> <u>1988</u>	<u>Probability</u> <u>1988</u>	<u>Chi Squared</u> <u>1993</u>	<u>Probability</u> <u>1993</u>
<u>Absolute Profit Efficiency</u>	$\alpha_i^* = \alpha_i^*, i=1,2,3$	201.36	.00	450.85	.00
<u>Constant Returns to Scale</u>	$\beta_T^* + \beta^* + \beta_T^* = 1$	15.20	.00	1.10	.29
<u>Chow Breakpoint Test for Pooling 1988 and 1993 Data</u>	<u>Test Statistic</u>	<u>Probability</u>			
<u>Log-Likelihood Ratio</u>	435.46	.00			
<u>F-Statistic</u>	45.77	.00			
<u>Shadow-price parameters</u>	<u>Parameters</u>	<u>1988</u>	<u>1993</u>		
<u>Fertilizer</u>	k_F	.43	-28.96		
<u>Organic Fertilizer</u>	k_O	-6.19	-22.67		
<u>Machine and Animal Inputs</u>	k_M	-1.60	11.13		

TABLE 3.4
REGRESSION RESULTS – PROFIT FUNCTION - AREAS WITH LAND ADJUSTMENT VERSUS
AREAS WITHOUT LAND ADJUSTMENT 1988 AND 1993

Profit Function	Parameter	OLS 1988	OLS 1993	Zellner SUR 1988	Zellner SUR 1993	
Variable and Fixed Inputs	Constant	1.47 ¹ (1.41)	4.98 ¹ (13.31)	3.64 ¹ (5.82)	5.24 ¹ (18.99)	
	Fertilizer	-1.52 ¹ (3.28)	.47 ¹ (3.29)	-.31 ¹ (1.11)	.53 ¹ (5.03)	
	Organic Fertilizer	1.14 ¹ (3.58)	1.29 ¹ (8.92)	.52 ¹ (2.72)	.99 ¹ (9.29)	
	Machine and Animal Inputs	.74 ¹ (2.03)	-.98 ¹ (7.45)	.17 ¹ (.79)	-.64 ¹ (6.58)	
	Sown Land	1.39 ¹ (34.32)	.92 ¹ (32.63)	1.19 ¹ (48.82)	.88 ¹ (42.45)	
	Household Labor	-.05 ¹ (.92)	.09 ¹ (1.94)	-.02 ¹ (.73)	.10 ¹ (3.08)	
	Household Capital	.03 ¹ (2.66)	-.05 ¹ (2.80)	.01 ¹ (2.44)	-.05 ¹ (3.53)	
	Land Tenure and Regional Dummy Variables					
		Administrative Land Readjustment (1=Yes)	-.13 ² (1.80)	-.09 ² (1.78)	-.02 ² (.37)	-.07 ¹ (1.54)
		Zhejiang	-2.06 ¹ (7.12)	-.46 ¹ (2.93)	-1.27 ¹ (7.31)	-.55 ¹ (4.76)
Jiangxi		-1.05 ¹ (9.78)	-3.65 ¹ (9.16)	-.75 ¹ (11.59)	-2.83 ¹ (9.63)	
Factor Demand Functions	Jilin	-.01 ¹ (.08)	-.26 ¹ (2.45)	-.20 ¹ (1.88)	-.48 ¹ (6.07)	
Fertilizer (Areas with No Land Adjustment)						
	Fertilizer (Areas with No Land Adjustment)	-.50 ¹ (5.86)	-.26 ¹ (14.93)	-.50 ¹ (5.86)	-.26 ¹ (14.95)	
	Fertilizer (Areas with Land Adjustment)	-.81 ¹ (7.25)	-.25 ¹ (22.11)	-.81 ¹ (7.26)	-.25 ¹ (22.14)	
	Organic Fertilizer (No Land Adjustment)	-.14 ¹ (7.11)	-.07 ¹ (7.60)	-.14 ¹ (7.12)	-.07 ¹ (7.61)	
	Organic Fertilizer (Land Adjustment)	-.14 ¹ (5.53)	-.07 ¹ (10.43)	-.14 ¹ (5.54)	-.07 ¹ (10.44)	
	Machine and Animal Inputs (No Land Adjustment)	-.84 ¹ (13.01)	-.35 ¹ (7.34)	-.84 ¹ (13.02)	-.35 ¹ (7.35)	
	Machine and Animal Inputs (Land Adjustment)	-.25 ¹ (2.96)	-.30 ¹ (9.82)	-.25 ¹ (2.96)	-.30 ¹ (9.83)	

Absolute Values of t-statistics are included in parentheses. 1= Significant at the .05 significance level; 2=Significant at the .10 significance level.

TABLE 3.5
HYPOTHESIS TEST RESULTS – COBB-DOUGLAS PROFIT FUNCTION - AREAS WITH LAND
ADJUSTMENT VERSUS AREAS WITHOUT LAND ADJUSTMENT

<u>Test</u>	<u>Parameters</u>	<u>Chi Squared</u> <u>1988</u>	<u>Probability</u> <u>1988</u>	<u>Chi Squared</u> <u>1993</u>	<u>Probability</u> <u>1993</u>
i) Equal Relative Economic Efficiency	$\delta_i^* = 0$.13	.71	2.39	.12
ii) Equal Relative Price Efficiency	$\alpha_i^{1*} = \alpha_i^{2*};$ $i = 1, 2, 3$	53.17	.00	.91	.82
iii) Equal Relative Technical and Price Efficiency	$\delta_i^* = 0$ and $\alpha_i^{1*} = \alpha_i^{2*};$ $i = 1, 2, 3$	59.07	.00	7.23	.12
iv) Absolute Price Efficiency of Farms without Land Adjustment	$\alpha_i^{1*} = \alpha_i^*;$ $i = 1, 2, 3$	155.50	.00	345.35	.00
v) Absolute Price Efficiency of Farms with Land Adjustment	$\alpha_i^{2*} = \alpha_i^*;$ $i = 1, 2, 3$	77.41	.00	408.41	.00
vi) Constant Returns to Scale	$\beta_T^* + \beta^* + \beta_T^* = 1$	23.00	.00	3.16	.07

Absolute Values of t-statistics are included in parentheses.

1 = Significant at the .05 significance level; 2 = Significant at the .10 significance level.

TABLE 3.6
REGRESSION RESULTS – COBB-DOUGLAS PROFIT FUNCTION –
AREAS WITH LAND FRAGMENTATION VERSUS AREAS WITHOUT LAND FRAGMENTATION

Profit Function	Parameter	OLS 1988	OLS 1993	Zellner SUR 1988	Zellner SUR 1993
Variable and Fixed Inputs	Constant	2.03 ¹ (1.96)	4.92 ¹ (12.99)	3.97 ¹ (6.36)	5.33 ¹ (19.07)
	Fertilizer				
Organic Fertilizer	α_F^*	-1.67 ¹ (3.62)	.46 ¹ (3.17)	-.38 (1.38)	.61 ¹ (5.69)
	α_O^*	.99 ¹ (3.15)	1.19 ¹ (9.02)	.42 ¹ (2.22)	.87 ¹ (8.96)
Machine and Animal Inputs	α_M^*	1.07 ¹ (2.88)	-.86 ¹ (6.94)	.36 (1.62)	-.57 ¹ (6.27)
	β_T^*	1.34 ¹ (31.98)	.91 ¹ (31.61)	1.15 ¹ (45.93)	.89 ¹ (41.79)
Household Labor	β_L^*	-.03 (.62)	.09 ² (1.94)	-.01 (.43)	.11 ¹ (3.15)
	β_K^*	.02 ² (1.84)	-.05 ¹ (3.08)	.01 (1.62)	-.05 ¹ (3.46)
Land Tenure and Regional Dummy Variables					
	Land Fragmentation (1=no)	.18 ¹ (3.83)	.05 (1.18)	.20 ¹ (4.53)	-.02 (.41)
Zhejiang	δ_2^*	-2.26 ¹ (7.72)	-.35 ¹ (2.43)	-1.38 ¹ (7.79)	-.42 ¹ (4.02)
	δ_4^*	-1.03 ¹ (9.88)	-3.27 ¹ (9.01)	-.74 ¹ (11.88)	-2.57 ¹ (9.61)
Jiangxi	δ_5^*				
	δ_6^*	-.01 (.04)	-.23 ¹ (2.16)	-.18 ² (1.76)	-.50 ¹ (6.06)
Jilin					
Factor Demand Functions					
	Fertilizer (Farms with Fragmented Land)				
Fertilizer (Farms with Less Fragmented Land)	α_F^{1*}	.90 ¹ (8.98)	-.27 ¹ (19.81)	-.90 ¹ (9.00)	-.27 ¹ (19.84)
	α_F^{2*}	-.38 ¹ (4.15)	-.24 ¹ (17.98)	-.38 ¹ (4.16)	-.24 ¹ (18.00)
Organic Fertilizer (Fragmented Land)	α_O^{1*}	-.20 ¹ (9.04)	-.09 ¹ (12.83)	-.20 ¹ (9.05)	-.09 ¹ (12.85)
	α_O^{2*}	-.08 ¹ (4.10)	-.04 ¹ (5.75)	-.08 ¹ (4.10)	-.04 ¹ (5.76)
Machine and Animal Inputs (Less Fragmented Land)	α_M^{1*}	-.66 ¹ (8.41)	-.30 ¹ (8.05)	-.66 ¹ (8.43)	-.30 ¹ (8.07)
	α_M^{2*}	-.60 ¹ (8.34)	-.33 ¹ (9.24)	-.60 ¹ (8.36)	-.33 ¹ (9.25)

Absolute Values of t-statistics are included in parentheses. 1 = Significant at the .05 significance level; 2 = Significant at the .10 significance level.

TABLE 3.7
HYPOTHESIS TEST RESULTS -- COBB-DOUGLAS PROFIT FUNCTION - AREAS WITH LAND
FRAGMENTATION VERSUS AREAS WITHOUT LAND FRAGMENTATION

<u>Test</u>		<u>Parameters</u>	<u>Chi Squared</u> 1988	<u>Probability</u> 1988	<u>Chi Squared</u> 1993	<u>Probability</u> 1993
i)	Equal Relative Economic Efficiency	$\delta_1^* = 0$	20.50	.00	.17	.68
ii)	Equal Relative Price Efficiency	$\alpha_1^1 = \alpha_1^2$; $i = 1, 2, 3$	21.96	.00	35.04	.00
iii)	Equal Relative Technical and Price Efficiency	$\delta_1^* = 0$ and $\alpha_1^1 = \alpha_1^2$; $i = 1, 2, 3$	36.06	.00	38.38	.00
iv)	Absolute Price Efficiency of Farms without Land Adjustment	$\alpha_1^1 = \alpha_1^2$; $i = 1, 2, 3$	161.52	.00	391.19	.00
v)	Absolute Price Efficiency of Farms with Land Adjustment	$\alpha_1^2 = \alpha_1^1$; $i = 1, 2, 3$	86.90	.00	369.40	.00
vi)	Constant Returns to Scale	$\beta_1^* + \beta_2^* + \beta_3^* = 1$	16.55	.00	2.09	.15

TABLE 3.8

REGRESSION RESULTS – COBB-DOUGLAS PROFIT FUNCTION –
LARGE FARMS VERSUS SMALL FARMS 1988 AND 1993

Profit Function	Parameter	OLS 1988	OLS 1993	Zellner SUR 1988	Zellner SUR 1993
Variable and Fixed Inputs	Constant	1.71 ¹ (1.65)	4.96 ¹ (13.07)	3.66 ¹ (5.83)	5.23 ¹ (18.66)
	Fertilizer	-1.59 ¹ (3.40)	.50 ¹ (3.50)	-.26 (9.1)	.55 ¹ (5.30)
Machine and Animal Inputs	Organic Fertilizer	1.10 ¹ (3.48)	1.19 ¹ (9.00)	.47 ¹ (2.48)	.88 ¹ (9.07)
	Sown Land	.83 ¹ (2.28)	-.89 ¹ (7.34)	.16 (7.4)	-.54 ¹ (6.07)
Household Labor	Household Capital	1.30 ¹ (23.30)	.93 ¹ (24.23)	1.19 ¹ (35.29)	.90 ¹ (31.57)
	Household Capital	-.04 (.66)	.09 ¹ (1.94)	-.02 (.72)	.10 ¹ (3.08)
Land Tenure and Regional Dummy Variables	Household Capital	.02 ¹ (2.49)	-.05 ¹ (2.93)	.01 ¹ (2.35)	-.05 ¹ (3.71)
	Farm Size (1=large)	.15 ¹ (2.01)	-.03 (.54)	.14 ¹ (2.32)	-.03 (.63)
Factor Demand Functions	Zhejiang	-2.11 ¹ (7.23)	-.35 ¹ (2.43)	-1.22 ¹ (6.93)	-.43 ¹ (4.10)
	Jilin	-1.13 ¹ (10.77)	-3.34 ¹ (9.33)	-.78 ¹ (12.30)	-2.50 ¹ (9.47)
	Jiangxi	.04 (.22)	-.24 ¹ (2.20)	-.17 (1.63)	-.45 ¹ (5.63)
Fertilizer (Small Farm)	α_F^{1*}	-.63 ¹ (5.62)	-.26 ¹ (19.46)	-.63 ¹ (5.62)	-.26 ¹ (19.48)
	α_F^{2*}	-.61 ¹ (7.06)	-.24 ¹ (18.32)	-.61 ¹ (7.07)	-.24 ¹ (18.34)
Fertilizer (Large Farm)	α_0^{1*}	-.22 ¹ (8.79)	-.07 ¹ (9.59)	-.22 ¹ (8.81)	-.07 ¹ (9.60)
	α_0^{2*}	-.09 ¹ (4.77)	-.06 ¹ (8.66)	-.09 ¹ (4.78)	-.06 ¹ (8.67)
Machine and Animal Inputs (Small Farm)	α_M^{1*}	-1.03 ¹ (12.27)	-.29 ¹ (7.97)	-1.03 ¹ (12.29)	-.29 ¹ (7.98)
	α_M^{2*}	-.38 ¹ (5.95)	-.33 ¹ (9.32)	-.38 ¹ (5.96)	-.33 ¹ (9.33)

Absolute Values of t-statistics are included in parentheses. 1= Significant at the .05 significance level; 2=Significant at the .10 significance level.

TABLE 3.9
HYPOTHESIS TEST RESULTS – COBB-DOUGLAS PROFIT FUNCTION –
LARGE FARMS VERSUS SMALL FARMS

<u>Test</u>	<u>Parameters</u>	<u>Chi Squared</u> <u>1988</u>	<u>Probability</u> <u>1988</u>	<u>Chi Squared</u> <u>1993</u>	<u>Probability</u> <u>1993</u>
i) Equal Relative Economic Efficiency	$\delta_1^* = 0$	5.39	.02	.39	.53
ii) Equal Relative Price Efficiency	$\alpha_i^{1*} = \alpha_i^{2*}; i = 1, 2, 3$	60.66	.00	7.23	.06
iii) Equal Relative Technical and Price Efficiency	$\delta_1^* = 0$ and $\alpha_i^{1*} = \alpha_i^{2*}; i = 1, 2, 3$	60.85	.00	7.95	.09
iv) Absolute Price Efficiency of Small Farms	$\alpha_i^{1*} = \alpha_i^*; i = 1, 2, 3$	150.03	.00	371.41	.00
v) Absolute Price Efficiency of Large Farms	$\alpha_i^{2*} = \alpha_i^*; i = 1, 2, 3$	98.76	.00	378.62	.00
vi) Constant Returns to Scale	$\beta_T^* + \beta^* + \beta_T^* = 1$	18.76	.00	1.50	.22

CHAPTER 4: LAND-TENURE INSTITUTIONS AND AGRICULTURAL PRODUCTIVITY: A TRANSLOG RESTRICTED PROFIT FUNCTION APPROACH

SECTION 4.1 INTRODUCTION

In addition to the Cobb-Douglas form of the profit function specified by Lau and Yotopoulos, researchers have used a variety of functional forms in applications of duality theory. One of the most popular functional forms used in empirical estimation is the translog. As discussed and applied to both profit functions and cost functions by Robert Halvorsen (1978), the translog form places minimal a priori conditions on the parameter estimations. This condition is particularly important if the researcher is attempting to gain estimates of the elasticities of demand and substitution. The Cobb-Douglas form restricts all cross-elasticities of substitution to equal unity.

This chapter re-estimates a restricted profit function similar to the profit function estimated in Chapter 3. However, in this case it applies a translog functional form in the estimation procedure to obtain a full set of estimates of elasticities of demand and substitution for all variable inputs. The results are also compared with those from the previous section to test the robustness of the findings with respect to the impact of the three land-tenure variables on economic efficiency. Finally, the section uses the parameter estimates from the translog profit function and share equations to estimate shadow values for the three fixed inputs, land, labor, and capital.

The estimated shadow values of land are compared for each of the tenure groups to gain an estimate of the impact land tenure variables may have on the return to land.

SECTION 4.2 THE TRANSLOG RESTRICTED PROFIT FUNCTION METHODOLOGICAL FRAMEWORK

Utilizing the notation used for the production function and Cobb-Douglas profit function described in Chapter 3 of this dissertation and the analytical framework outlined by Halvorsen (1978), a transcendental logarithmic (translog) normalized restricted profit function can be specified. The translog profit function for the three variable inputs and three fixed inputs used in this paper is written as:

$$\begin{aligned}
 \ln \Pi^* = & \ln A^* + \sum_i \alpha_i^* \ln q_i + \frac{1}{2} \sum_i \sum_h \gamma_{ih}^* \ln q_i \ln q_h + \sum_i \sum_j \phi_{ij}^* \ln q_i \ln Z_j \\
 (4.1) \quad & + \sum_j \beta_j^* \ln Z_j + \frac{1}{2} \sum_j \sum_k \phi_{jk}^* \ln Z_j \ln Z_k + \sum_m \delta_m D_m \\
 & i, h = F, O, M; j, k = T, L, K; m = 1, 2, 3
 \end{aligned}$$

where Π^* is restricted profit per household (calculated by subtracting current variable costs from current revenue and normalized by the price of output); q_F^* is the price of chemical fertilizer; q_O^* is the price of organic fertilizer; q_M^* is the price of machine and animal inputs; Z_T^* is sown land area of the household; Z_L^* is the household labor force; Z_K^* is the amount of fixed capital per household; D_1 is a dummy variable representing whether or not a village has experienced a land reallocation (1=yes); D_2 is a dummy variable representing land parcel size (1=large parcels); and D_3 is a dummy variable representing farm size (1=large).

$-X_i^*$

Hotelling's Lemma implies that $\frac{\partial \Pi}{\partial q_i} = -X_i^*$, where $-X_i^*$ is the profit maximizing amount of input i . Profit share equations for each of the variable inputs can be obtained using Hotelling's Lemma and logarithmic differentiation of the normalized restricted profit function:

$$(4.2) \quad -\frac{\partial \ln \Pi}{\partial \ln q_i} = -\frac{\partial \Pi q_i}{\partial q_i \Pi} = \frac{P_i X_i^*}{\Pi} = M_i =$$

$$-(\alpha_i + \sum_h \gamma_{ih} \ln q_h + \sum_j \varphi_{ij} \ln Z_j) \quad i, h = F, O, M; j = T, L, K$$

where M_i is the ratio of normalized expenditures on fuel i to normalized restricted profit.

The equations to be estimated in this system include 4.1 and the three equations implied by 4.2. The equations are estimated using most of the same data that was used in the empirical estimations in Chapter 3. Two minor alterations were made to the data used in the current equations. First, labor input in hours was used in the place of number of available workers to facilitate the estimation of a shadow wage rate. To ensure that this switch in variables did not alter the overall results, regressions using both labor specifications and translog and Cobb-Douglas functional forms were estimated. The change in measurements did not significantly alter the results in any of the four cases.

Another change in the included variables is that the regional dummy variables are not included in the translog specification because their interaction with other variables completely identified the system and prevented estimation. As these variables were significant in the Cobb-Douglas case, their exclusion in the current case is not optimal, but is unavoidable. Finally, restrictions are imposed on the system

such that $\gamma_{ih}=\gamma_{hi}$ and $\phi_{jk}=\phi_{kj}$. Such restrictions are included in almost all translog estimations, and are often referred to as “symmetry” or “equality restrictions”.

As described by Halvorsen (1978), a normalized restricted profit function is well behaved if it is strictly decreasing and convex in the normalized prices and strictly increasing in the fixed inputs. Several tests of the behavior conditions of the restricted profit function exist. First, the condition that the restricted profit function is strictly decreasing in prices can be checked by examining the fitted expenditure ratios described in equation 4.2. The fitted ratios should be positive because both profits and prices of the variable inputs are all positive. Second, a test that the restricted profit function is strictly increasing in fixed inputs can be conducted by examining the shadow values of the fixed inputs. The shadow values of the fixed inputs can be calculated by:

$$(4.3) \quad \frac{\partial \Pi}{\partial Z_j} = \frac{\Pi}{Z_j} \left(\sum_h \gamma_{jh} \ln q_h + \beta_j + \sum_k \phi_{jk} \ln Z_k \right) \quad i = F, O, M; j, k = T, L, K.$$

Finally, the convexity of the restricted profit function with respect to the prices of the variable inputs can be checked by examining the signs of the own-price elasticities of demand. Strict convexity is maintained if the own-price elasticity is positive across each input and household. Own-price elasticities of demand can be calculated using parameter estimates from the translog profit equation and the profit share equations. The formula is:

$$(4.4) \quad E_{ii} = \frac{q_i \partial^2 \Pi / \partial q_i^2}{\partial \Pi / \partial q_i} = \frac{-M_i^2 - M_i - \gamma_{ii}}{M_i} \quad i = F, O, M.$$

Cross-price elasticities of demand can be calculated using a similar procedure:

$$(4.5) \quad E_{ih} = \frac{q_h \partial^2 \Pi / \partial q_i \partial q_h}{\partial \Pi / \partial q_i} = \frac{-M_i M_h - \gamma_{ih}}{M_i} \quad i, h = F, O, M.$$

Partial elasticities of substitution can be obtained as normalized price elasticities. The relevant equations are:

$$(4.6) \quad \sigma_{ii} = \frac{1}{M_i} E_{ii} = \frac{-M_i^2 - M_i - \gamma_{ii}}{M_i^2} \quad i = F, O, M \text{ and}$$

$$(4.7) \quad \sigma_{ih} = \frac{1}{M_h} E_{ih} = \frac{-M_i M_h - \gamma_{ih}}{M_i M_h} \quad i, h = F, O, M$$

The partial elasticities of substitution thus obtained are invariant to the ordering of the factors, such that $\sigma_{ih} = \sigma_{hi}$. This condition is not necessarily true of the cross-elasticities, since in general $E_{ih} \neq E_{hi}$. As pointed out by Halvorsen, the partial elasticities defined using this method are similar to, but not identical to, the Allen partial elasticities of substitution. The two differ in that quantities are held constant in the current case, while the prices of the fixed factors are held constant in the Allen case.

SECTION 4.3 ESTIMATION RESULTS

The system described by the equation 4.1 and the three equations in 4.2 is estimated using an iterative Zellner SUR procedure. The results of the Zellner procedure are identical to the maximum likelihood estimations. The simultaneous estimation of the system of equations provides results that are efficient and consistent, as opposed to equation by equation estimation using OLS. The parameter estimates and t-statistics from the estimation of the system of equations outlined in 4.1 and 4.2

are reported in Table 4.1. The estimation procedure is conducted for data from both 1988 and 1993.

As with the Cobb-Douglas functional form, many of the parameters on the variables in the translog function in both time periods are highly significant, including the parameters for the land-tenure variables. A Chow break-point test to determine the feasibility of pooling the data from the two time periods was conducted. The results of this test are reported in Table 4.2. As was true for the Cobb-Douglas specification, the hypothesis of stability across the two time periods was rejected for the translog function based on both the F-statistic test and the log-likelihood ratio test.

Also reported in Table 4.2 is a test to check the significance of the change in functional form. This test uses a log-likelihood test to compare the results achieved using the translog functional form versus those achieved in the previous section using the Cobb-Douglas form. As described by Atkinson and Halvorsen (1980), the results between the two functional forms can be tested by computing $-2\log\lambda$, where λ is the ratio of the maximum value of the likelihood function for the restricted equations to the maximum value of the likelihood function for the unrestricted equations. The test statistic is distributed asymptotically as χ^2 with degrees of freedom based on the number of restrictions imposed. The Cobb-Douglas functional form is a special case of the translog form in which all cross-terms are restricted to equal unity. In the empirical specification used in this paper, the number of restricted cross-terms in the Cobb-Douglas case is 21. The critical value of the χ^2 test statistic with 21 degrees of freedom and a significance level of .005 is 8.03. As can be seen in Table 4.2, the null-hypothesis of no significant difference in the functional form used can not be rejected for either 1988 or 1993. Therefore, while the translog form may be considered superior in certain respects because of the minimal a priori constraints it places on the

parameter estimations, in the current case the alternative Cobb-Douglas functional form can not be dismissed as inefficient.

The parameters on the land tenure variables are generally similar in sign and significance to those in the Cobb-Douglas case, although several differences can be noted. For 1988, the results between the two functional forms are identical, with the parameter on households experiencing a land adjustment being negative and significant, the parameter on parcel size being positive and significant and the parameter on farm size not being significant. As before, these results indicate that poor tenure security through land readjustments and land fragmentation reduced economic efficiency, while farm size had no effect on economic efficiency.

In 1993, the results reported for the translog function are different from those in the Cobb-Douglas case in several aspects. For example, the translog results indicate that land fragmentation significantly reduced economic efficiency in 1993. This result matches economic theory and the findings from 1988, but is the opposite of the finding from the Cobb-Douglas case. Additionally, in the translog form neither of the other two variable coefficients is significant. This result is similar to the results for the Cobb-Douglas form with regard to the finding for farm size, but the insignificant result for the parameter on land readjustment differs from the Cobb-Douglas case where this parameter was found to be significantly negative.

The translog system of equations used, like the Cobb-Douglas system used earlier, does not impose profit maximization on the parameters. To test for profit maximization given the new functional form, F-tests were conducted to compare the parameter estimates for the variable input prices obtained from the profit function with those obtained from the profit share equations. Acceptance of the hypothesis of profit maximization would indicate that the two sets of parameters are statistically

equivilient. However, as reported in Table 4.2, this hypothesis is rejected for both time periods. This result is not surprising given the clear rejection of profit maximization reported earlier for the Cobb-Douglas estimations.

As was described earlier, several tests are available to check the conditions of the estimated translog restricted profit function to see if they are well behaved. First, the condition that the translog restricted profit function be decreasing in the prices of the variable inputs can be tested by checking the signs of the fitted profit share ratios for each household. For a well-behaved function, all the fitted ratios should be positive. In 1988, 100.0 percent of the fitted ratios for fertilizer, 89.5 percent of the fitted ratios for organic fertilizer, and 91.6 percent of the fitted ratios for machine and animal inputs are positive. In 1993, 100.0 percent of the fitted ratios for fertilizer, 42.5 percent of the fitted ratios for organic fertilizer, and 41.5 percent of the fitted ratios for machine and animal inputs are positive. These results indicate that the condition that the translog profit function be decreasing in the prices of the variable inputs is violated for numerous households, particularly in 1993. This result is similar to the finding of positive coefficients on a number of the variable input prices in the Cobb-Douglas profit function regressions reported earlier.

A second test involves the shadow prices of the fixed inputs. The shadow prices reflect the partial derivative of restricted profit with respect to the fixed input, and all should be positive if the profits are strictly increasing in the amounts of the fixed inputs. The mean shadow prices of the fixed inputs for the households in the survey are recorded in Table 4.3. As reported, the mean shadow prices of all fixed inputs are positive except for the shadow price of labor in 1988. Some of the individual household estimates of the shadow prices for labor and capital in both 1988 and 1993 are also negative, even when the mean value for the sample is positive. All estimates of the shadow price of land are positive for both years. Similar results were

obtained in the estimation of the Cobb-Douglas function, and may indicate errors in the measurement of the variables in question or inefficiencies in markets in China that cause the marginal product of fixed factors such as labor to be negative.

Despite the variations from economic theory, the estimated shadow prices do provide some useful information on the return to fixed factors in China. For example, the shadow price of labor indicates that the real wage in Chinese agriculture was negative in 1988 and positive, but very low, in 1993. The estimated shadow wage for 1993 indicates that the value of the marginal product of labor was approximately 0.9 Yuan per day, assuming a 10-hour work day¹⁴. While this rate seems very low, it is higher than the estimate of 0.22 to 0.27 Yuan per work day obtained by Calla Wiemer for data covering 1985 and reported in Putterman (1993). The low value for the marginal product of labor in China is related to the large number of laborers available for the small amount of land that households farm. In most areas, few off-farm work opportunities are available for surplus labor, therefore the labor remains engaged in agricultural production even when returns to labor are very low.

The shadow price of capital provides an indication of the return to fixed capital in Chinese agriculture. The estimated marginal return on fixed capital in this estimation for both 1988 and 1993 is approximately 17 percent. This return rate likely understates the true return to capital because the study does not take into account the depreciation of household fixed capital due to the absence of an appropriate discount rate. The return obtained here is higher than that obtained by Calla Wiemer, who finds a negative marginal product for capital in the crop sector for each year from 1980 to 1985 (Putterman 1993).

¹⁴ The official exchange rate in 1993 was Y5.76=US\$1.00.

With regard to the marginal return to land, the estimation records a mean shadow price per mu of land of 357.5 Yuan in 1988 and 353.0 in 1993. The two figures are not directly comparable because the two samples contain different households, but do provide an indication that returns to land did not increase much over the 5-year time period¹⁵. One interesting exercise that can be carried out is to compare the average returns to land among the different land tenure groups. The mean return to land for each group is reported in Table 4.3. Among the interesting findings in this analysis, the marginal product of land for areas with land readjustments is 21 percent lower in both 1988 and 1993 than the marginal product of land for areas without readjustments. The findings of lower economic efficiencies and lower marginal products of land in areas with poor tenure security may reflect the lower level of investment in land in these areas, as was indicated in the Li (1998) and Carter and Yao (1998) studies.

Other figures in this table indicate that the returns to land for small farms is higher in both time periods than the returns to land for large farms, a finding supporting results from other developing countries. However, farm size was not found to influence economic efficiency in either time period in both functional form specifications. This result may also be related to the earlier discussed problem of omitted variable bias. A puzzling result for land parcel size and fragmentation indicates that large parcels had higher returns in 1988, but lower returns in 1993. This finding is puzzling because the translog profit function estimations found that households with large parcels displayed greater economic efficiency in both time periods compared to households with small, fragmented parcels.

¹⁵ As in the Cobb-Douglas regressions, a number of households were excluded from the translog profit function estimations due to insufficient data or negative profits. In both cases, in 1988 the number of households included in the analysis was 618, while in 1993 the number included was 749.

One of the benefits of using the translog functional form is that the translog form allows the computation of the cross-elasticities of price and substitution in addition to the own-price and substitution elasticities. Table 4.4 reports the own- and cross-price elasticities of demand, while Table 4.5 reports the partial elasticities of substitution. The computation of the elasticities allow their estimation for each household in the sample, and estimates reported in the tables are the mean values for the elasticities across the sample years.

All but one of the mean own-price elasticities reported in Table 4.4 have the expected negative sign. Only the estimate for machine and animal inputs in 1988 is positive. While the means of the own-price elasticities are generally well behaved, the standard deviations for several of the estimates are quite large. Therefore several of the individual household estimates for machine and animal inputs and organic fertilizer have incorrect signs, an indication that the profit function is not convex for all observations. The cross-price elasticities of demand do not have a priori expected signs. Input pairs with positive coefficients are substitutes and input pairs with negative coefficients are compliments in production. Once again the standard deviations reported are quite large. The pairs of inputs that are reported to be compliments and those that are reported to be substitutes vary across the sample and years, and no clear relationships emerge.

The own and cross partial elasticities of substitution are reported in Table 4.5. Once again the own factor elasticities are expected to be negative, which is true for 5 of 6 reported coefficients. All of the cross-elasticities of substitution are negative, indicating complementarity between the variable factors of production. However, the standard errors on these estimates are generally quite large. Therefore individual households display a wide range of results, and it is difficult to make generalizations

about the complementarity of substitutability of the variable factors of production across the sample areas.

SECTION 4.4 CONCLUSION

This section of the paper carried out an estimation of the restricted profit function using a translog functional form. The advantage of the translog form is that, unlike the Cobb-Douglas functional form, the translog does not restrict the cross-terms between the factors to equal unity. This places minimal a priori conditions on the estimation, and allows the calculation of both own- and cross-price and substitution elasticities. The results reported in this section for the most part confirm the findings from the Cobb-Douglas estimation carried out in Chapter 3 using the Lau and Yotopoulos framework of analysis.

For example, land readjustments that lead to poor tenure security significantly reduce the economic efficiency of agricultural production. One measure of this reduction in efficiency that is generated in this section involves the shadow price of land in areas with secure tenure and areas without secure tenure. Areas with secure tenure reported marginal values of land approximately 21 percent higher than areas without secure tenure in both time periods. Land fragmentation was also found to significantly reduce economic efficiency in agricultural production, while farm size did not significantly affect production.

One advantage of using the translog form is that it allows estimation of the full set of own- and cross- price and substitution elasticities. This paper offers the first published attempt to calculate these elasticities. At their mean values, most of the elasticities have the expected sign. However, the large standard deviations for the

reported elasticities indicate that at a household level, wide variations exist in the substitutability and complementarity of the variable inputs examined.

TABLE 4.1 (PART A)

ESTIMATION RESULTS – TRANSLOG PROFIT FUNCTION –
PROFIT FUNCTION PARAMETERS

<u>Profit Function</u>	Zellner SUR 1988		<u>Profit Function</u>	Zellner SUR 1993
Parameter			Parameter	
lnA*	11.01 (0.81)		lnA*	21.43 ¹ (5.46)
α_F^*	-12.61 ² (1.83)		α_F^*	7.55 ¹ (4.16)
α_O^*	-0.62 (0.07)		α_O^*	-5.98 ¹ (5.70)
α_M^*	6.41 ¹ (2.20)		α_M^*	-3.12 ¹ (2.66)
γ_{FF}^*	-8.52 ¹ (7.77)		γ_{FF}^*	2.38 ¹ (3.42)
γ_{OO}^*	-0.52 (0.20)		γ_{OO}^*	1.27 ¹ (4.40)
γ_{MM}^*	-3.86 ¹ (2.29)		γ_{MM}^*	-0.66 ¹ (2.68)
γ_{FO}^*	4.51 ¹ (2.02)		γ_{FO}^*	-1.51 ¹ (4.44)
γ_{FM}^*	4.81 ¹ (2.09)		γ_{FM}^*	-0.75 ¹ (2.01)
γ_{OM}^*	-2.29 ¹ (2.76)		γ_{OM}^*	1.01 ¹ (4.51)
β_L^*	-0.31 (0.43)		β_L^*	-0.60 (1.02)
β_T^*	2.10 ¹ (2.71)		β_T^*	-0.76 (1.34)
β_K^*	-0.53 ² (1.82)		β_K^*	0.05 (0.21)
ϕ_{LL}^*	0.03 (0.43)		ϕ_{LL}^*	0.05 (1.00)
ϕ_{TT}^*	-0.02 (0.38)		ϕ_{TT}^*	-0.27 ¹ (4.17)
ϕ_{KK}^*	0.00 (0.37)		ϕ_{KK}^*	-0.00 (0.16)
ϕ_{LT}^*	0.05 (1.11)		ϕ_{LT}^*	0.10 ¹ (2.26)
ϕ_{LK}^*	-0.02 ¹ (2.43)		ϕ_{LK}^*	-0.03 (0.83)
ϕ_{TK}^*	-0.00 (0.53)		ϕ_{TK}^*	0.07 ¹ (1.97)
ϕ_{FL}^*	-0.03 (0.27)		ϕ_{FL}^*	-0.29 ¹ (3.23)
ϕ_{FT}^*	0.36 ¹ (2.63)		ϕ_{FT}^*	0.30 ¹ (2.84)
ϕ_{FK}^*	-0.12 ¹ (2.70)		ϕ_{FK}^*	-0.00 (0.13)
ϕ_{OL}^*	-0.03 (0.14)		ϕ_{OL}^*	0.00 (0.05)
ϕ_{OT}^*	-0.38 (1.64)		ϕ_{OT}^*	0.15 ¹ (2.26)
ϕ_{OK}^*	0.25 ¹ (2.81)		ϕ_{OK}^*	0.04 (1.19)
ϕ_{ML}^*	0.26 ¹ (2.19)		ϕ_{ML}^*	0.12 ² (1.88)
ϕ_{MT}^*	0.02 (0.23)		ϕ_{MT}^*	0.17 ¹ (2.96)
ϕ_{MK}^*	-0.16 ¹ (4.71)		ϕ_{MK}^*	-0.08 ¹ (2.67)
δ_1	-0.13 ¹ (3.12)		δ_1	0.02 (0.43)
δ_2	-0.03 (0.69)		δ_2	0.02 (0.38)
δ_3	0.12 ¹ (3.68)		δ_3	0.18 ¹ (3.98)

Absolute Values of t-statistics are included in parentheses.

1= Significant at the .05 significance level. 2=Significant at the .10 significance level.

See Estimations of Profit Share Equation Parameters on next page.

TABLE 4.1 (PART B)

ESTIMATION RESULTS – TRANSLOG PROFIT FUNCTION –
PROFIT SHARE EQUATION PARAMETERS

<u>Profit Share Equations</u>	Zellner SUR 1988		<u>Profit Share Equations</u>	Zellner SUR 1993
Parameter			Parameter	
α_F^*	-0.26 (0.27)		α_F^*	-0.65 ¹ (3.60)
γ_{FF}^*	0.53 ¹ (2.79)		γ_{FF}^*	-0.10 ¹ (4.51)
γ_{FO}^*	-0.01 (0.27)		γ_{FO}^*	-0.05 ¹ (5.33)
γ_{FM}^*	-0.39 ¹ (3.44)		γ_{FM}^*	0.07 ¹ (4.46)
ϕ_{FL}^*	-0.11 (0.90)		ϕ_{FL}^*	0.03 (1.63)
ϕ_{FT}^*	0.06 (0.55)		ϕ_{FT}^*	-0.03 ² (1.83)
ϕ_{FK}^*	0.03 (1.09)		ϕ_{FK}^*	0.06 ¹ (6.24)
α_O^*	0.12 (0.40)		α_O^*	-0.20 ¹ (2.07)
γ_{OO}^*	-0.02 (0.26)		γ_{OO}^*	0.00 (0.32)
γ_{OM}^*	0.03 (0.85)		γ_{OM}^*	0.04 ¹ (5.36)
ϕ_{OL}^*	-0.09 ¹ (3.24)		ϕ_{OL}^*	4.09 (0.00)
ϕ_{OT}^*	0.17 ¹ (6.61)		ϕ_{OT}^*	-0.01 (1.29)
ϕ_{OK}^*	0.00 (0.34)		ϕ_{OK}^*	0.01 ¹ (3.14)
α_M^*	-2.39 ¹ (3.53)		α_M^*	-1.96 ¹ (4.94)
γ_{MM}^*	-0.49 ¹ (4.01)		γ_{MM}^*	0.11 (2.85)
ϕ_{ML}^*	0.11 (1.26)		ϕ_{ML}^*	0.15 ¹ (3.18)
ϕ_{MT}^*	0.35 ¹ (4.08)		ϕ_{MT}^*	-0.15 ¹ (3.32)
ϕ_{MK}^*	0.02 (0.91)		ϕ_{MK}^*	0.10 ¹ (4.48)

Absolute Values of t-statistics are included in parentheses.

1= Significant at the .05 significance level. 2=Significant at the .10 significance level.

TABLE 4.2
HYPOTHESIS TEST RESULTS – TRANSLOG PROFIT FUNCTION

<u>Test</u>	<u>Test Statistic</u> 1988	<u>Critical Value</u> (df=21 signif. =.005)	<u>Test Statistic</u> 1993	<u>Critical Value</u> (df=21 signif. =.005)
Log-Likelihood Test for Cobb-Douglas vs. Translog Functional Form	0.33	8.03	0.15	8.03
	<u>Test Statistic</u>	<u>Probability</u>		
Chow Breakpoint Test for Pooling 1988 and 1993 Data				
Log-Likelihood Ratio	327.29	.00		
F-Statistic	12.65	.00		

TABLE 4.3
SHADOW PRICES OF FIXED INPUTS - TRANSLOG PROFIT FUNCTION

	1988	1993
Shadow Price of Labor (Yuan per hour)	-0.13	0.09
Shadow Price of Capital (Return in Yuan per Yuan of capital)	0.17	0.17
Shadow Price of Land (Yuan per mu)		
Whole Sample	357.50	353.02
Areas with Adjustment	315.32	331.64
Areas without Adjustment	382.34	402.81
Areas with Large Parcels	393.52	279.80
Areas without Large Parcels	314.31	428.03
Large Farms	353.07	265.92
Small Farms	365.09	445.65

TABLE 4.4
PRICE ELASTICITIES OF DEMAND – TRANSLOG PROFIT FUNCTION

	1988	1993
Own Price Elasticities		
Fertilizer (E_{FF})	-1.45	-0.28
Organic Fertilizer (E_{OO})	-0.69	-0.01
Machine and Animal Inputs (E_{MM})	0.73	-0.75
Cross-Price Elasticities		
Fertilizer - Organic Fertilizer (E_{FO})	-0.09	0.14
Fertilizer - Machine and Animal (E_{FM})	0.14	-0.15
Organic Fertilizer - Machine and Animal Input (E_{OM})	-0.91	0.34
Organic Fertilizer - Fertilizer (E_{OF})	-0.47	-0.82
Machine and Animal Input - Fertilizer (E_{MF})	0.22	-0.37
Machine and Animal Input - Organic Fertilizer (E_{MO})	-0.23	0.11

TABLE 4.5

PARTIAL ELASTICITIES OF SUBSTITUTION - TRANSLOG PROFIT FUNCTION

	1988	1993
Fertilizer – Fertilizer (σ_{FF})	-5.97	-2.66
Organic Fertilizer – Organic Fertilizer (σ_{OO})	-4.28	5.27
Machine and Animal Input – Machine and Animal Input (σ_{MM})	-0.47	-1.74
Fertilizer – Organic Fertilizer (σ_{FO})	-0.73	-2.30
Fertilizer – Machine and Animal Input (σ_{FM})	0.42	-0.53
Organic Fertilizer – Machine and Animal Input (σ_{OM})	-1.59	-5.10

CONCLUSION

This dissertation seeks to explain and examine the link between land-tenure institutions and agricultural productivity in China. It offers contributions to two bodies of economic literature. The first is the worldwide literature on land-tenure institutions and agricultural productivity. The second is the literature on agricultural development and food security issues in China. The information presented in the four chapters of the paper offer one of the only comprehensive examinations of the land tenure situation in China in the late 1980's and early 1990's. The results of this dissertation are applicable not only to China, but also to other developing countries. The results are especially relevant to other countries in the process of transitioning from socialism to a market-oriented economy.

The first chapter provides an overview of the historical development of the land-tenure system under the HRS, and introduces several possible inefficiencies in the land-tenure system. The second chapter introduces the unique data set that was used in the empirical studies in the dissertation. The data set is one of the only data sets gathered specifically to study the land-tenure system and agricultural productivity in China. It is unique in the breadth of information it provides on the land-tenure situation at both the village and household level. Examination of the data reveals that land-tenure rules across the country show a surprising diversity. This diversity is found to exist despite clear central government pronouncements promoting individualized land rights such as land transfer rights and secure land tenure for rural households. This finding indicates that local village officials may have significant influence over the setting of local land rights in China.

The third and fourth chapters of the dissertation examine the link between land-tenure institutions and household agricultural production. These chapters adopt a

restricted profit function approach to the study of land-tenure institutions. The empirical applications represented the first time that a restricted profit function approach has been applied to the study of certain land-tenure measures such as land-tenure security and land fragmentation. Both Cobb-Douglas and translog functional forms are estimated, and the results indicate that land-tenure institutions significantly influence agricultural productivity in China. Poor land-tenure security, land fragmentation and small farm size are all shown to reduce household productivity in agriculture.

Despite several problems reported with respect to the behavior of the profit-functions in Chapters 3 and 4, duality theory offers promise for the study of land-tenure rights and agricultural productivity in China and other countries. In terms of empirical estimation procedures, several extensions to the work presented in the paper are possible. While the fact that the current data set does not directly record input and output prices hampers its effectiveness, it may be possible to reexamine the data to gain better measures of observed prices. Improved estimates of price parameters may reduce or eliminate the problems encountered with the poor behavior of the profit function with regard to variable input prices.

Improved price estimations may also allow the estimation of cost functions instead of profit functions for agricultural households. Cost function estimation requires fewer restrictions because households are assumed to only minimize cost, and are not required to simultaneously minimize cost and determine the optimal output level as required in profit maximization. Attempts to estimate cost functions using the price parameters used in this paper were stymied by the limited variability in the data due to the use of county-level prices.

Perhaps the most effective extension of the paper would involve acquiring an improved data set that includes measures of both important input and output price

parameters and land-tenure variables. This might be achieved by locating information on village or county prices to match with the current data set, or through the collection or acquisition of a new data set. Despite extensive research, the author was unable to locate price tables for any agricultural inputs. Agricultural output prices were only available at a provincial level. With improved data, the estimation techniques used in this paper could be reapplied to gain more robust results. It might also be possible to utilize a two-stage estimation technique similar to that in Wang et al (1996) to gain direct estimation of shadow price parameters, household technical efficiency parameters, and the factors affecting household technical efficiency. These estimations were not possible using the current data set problems such as the finding of negative shadow price parameters. Such parameters prevent estimation because they appear in a log form in the estimation procedure.

It is important to note, however, that an understanding of the political economy of land tenure in China is necessary before lasting reforms of land-tenure institutions can be accomplished. For example, the level and process by which land regulations are developed must be understood before attempts are made to change their structures. The early chapters of the paper detailed central government efforts to improve land-tenure institutions in the country by promoting greater tenure security and individualization of land rights. However, the paper also showed that land-tenure institutions continue to show great diversity across village areas, and local village officials are likely to play a key role in the setting of village-level land policy.

Any effort to reform the land-tenure system in China will have to take this political economy situation into account. More pronouncement and rules by the central government are unlikely to have much impact on household land tenure without more far reaching changes in land management. The central government must either find a way to enforce its policy pronouncements despite local officials, or

incentives for local officials must be brought in line with those of the central government. Because of the decentralized nature of power in China, it is likely that any effort to improve land rights in China will need to include village leaders as a partner. More work is necessary to explore governmental options for improving enforcement of land regulations. This work should focus on understanding the motivations and actions of local officials with regard to applied land-tenure policy and on finding appropriate incentive structures to ensure that the incentives of local leaders ensure the maximum level of social welfare.

The descriptive and empirical work contained in this dissertation provides important information for understanding agricultural production in China under the Household Responsibility System. These results tend to confirm the findings of other researchers with regard to land-tenure impacts in China, and therefore add additional evidence that the organization of land-tenure institutions must be considered in attempts to improve agricultural productivity in the country. The results indicate that improvements in tenure security and other household land rights should lead to increases in agricultural productivity. Because changes to “the rules of the game” do not require the addition of a large amount of scarce physical resources, the amount of investment necessary to increase production by improving the land-tenure system is relatively low. Therefore, improvements to the land-tenure system provide a promising and relatively inexpensive way for the Chinese government to increase agricultural production.

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Primary Fields: Economic Development, Environmental and Natural Resource Economics.

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M.A. in Economics, University of Washington, Seattle, WA, completed March 1997.

Fellowships and Honors:

- University of Washington Ensley Fellowship in Public Policy (1997-1998)
- University of Washington Henry M. Jackson Fellowship in China Studies (1994-1997)
- National Security Education Program (NSEP) Fellowship (1994-1997)
- Social Science Research Council (SSRC) Dissertation Field Research Fellowship (1997)
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M.A. in International Economics and China Studies,

Johns Hopkins School of Advanced International Studies (SAIS),

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Coursework included: Advanced International Trade and Monetary Theory, Trade and Capital Flows in Economic Development, and the Economic Development, Politics and History of Modern China.

Proficient in spoken and written Mandarin Chinese, including one year of language study in Beijing, China.

B.A. in Economics and Management, Rice University, Houston, TX, May 1988.

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Non-Academic Work Experience

- The Soros Foundation Enterprise Privatization Project , Ulaanbaatar, Mongolia, Fall 1997. Consultant. Worked as an advisor to the Mongolian Government on the design and implementation of the national privatization program for state-owned enterprises.
- The World Bank Foreign Investment Advisory Service, Ulaanbaatar, Mongolia, Fall 1996. Consultant. Assisted in the development and operation of the Roundtable on Foreign Direct Investment in Mongolia. Assisted in the preparation of seminar papers on the role of FDI in Mongolia's economic development, and FDI regulation and promotion.
- The World Bank, Washington, DC, May - August 1996. Summer Associate. Assisted in the research and writing of the World Bank Policy Paper, "Best Practices in Land Tenure Reform." Developed best practice guidelines, case studies and lessons learned from land tenure reform programs worldwide.
- Mongolia Business Services, Seattle, WA September 1994 - present
Editor and publisher of the *Mongolia Monthly* newsletter and *Mongolia NewsBrief* weekly fax news service. Also provide consulting services to business clients.
- U.S.-Mongolia Business Council, Washington, DC, September 1993- June 1994. Developed and ran Council operations, organized conferences, published a monthly newsletter and provided market research for US companies investing in Mongolia.
- Cometals China, Beijing, P. R. China, September 1992- June 1993. Beijing Office Manager for a Fortune 500 minerals and metals trading company.
- U.S. Embassy, Ulaanbaatar, Mongolia, May - August 1992. Economic and Political Affairs Assistant, drafted reporting cables on business opportunities, economic development and Mongolia's first democratic parliamentary elections.
- Office of the U.S. Trade Representative (USTR), Washington, DC, Sep. 1991-June 1992. Assistant in the Office of Chinese and Japanese Affairs, provided support for trade negotiations between China and the US on Market Access and Intellectual Property Rights issues.
- Fortune Magazine, New York, NY, May - August 1987, May - August 1988
Worked as a full-time reporter conducting interviews, researching and fact-checking. Published four by-line articles in the magazine.

Professional Affiliations:

Association for Comparative Economic Studies (ACES); Chinese Economists Society (CES)

Academic Conference Presentations:

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Instructor, China's Economic Reforms, Spring 1999

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