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United States Meat Goat Production Economic Performance Measures: A Stochastic Production Frontier Analysis

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UNITED STATES MEAT GOAT PRODUCTION ECONOMIC PERFORMANCE MEASURES:
A STOCHASTIC PRODUCTION FRONTIER ANALYSIS

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by
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This work is dedicated to my parents, Qushim and Oysafar, who passed away in May 1995 and in October 2003.

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ABSTRACT

The meat goat industry is relatively a newcomer to the U.S. agricultural production and one of the fastest growing livestock industries in the U.S. Despite the growth of the meat goat industry, little is known about meat goat production economics. Information is needed concerning the drivers of production efficiency, optimum size of operation, and scope economies in the industry. A nationwide mail survey of U.S. meat goat producers who advertise their meat goat production via the internet for this efficiency analysis was conducted. Costs and returns data for 2011 expenses from those meat goat producers were collected. This survey was a follow-up to an earlier survey that focused on the marketing, technology, farmer attitudes and farm/farmer characteristics associated with U.S. meat goat production. Since the motivations for the follow-up costs and returns survey were to estimate U.S. meat goat farm efficiency and determine the efficiency drivers, we also used demographics and farm characteristics from the first meat goat survey.

The input distance function analysis showed that the impact of specialization of farm production (percentage of income from the goat enterprise), the effect of production system, and the effect of targeted market on meat goat farm technical efficiency were significant. Off-farm work, education, experience, age and gender (female) have impacts on the technical efficiency of U.S. meat goat farms. Increasing returns to scale on U.S. meat goat farms suggests that producers can increase the size of their operations, resulting in less overall input usage per unit produced. Scope economies in Southeastern U.S. meat goat production suggest reduced long run average cost of production via diversification. The research results suggest that U.S. meat goat farms can be scale efficient if their optimal size of operation is greater than approximately 64 goats or greater than 40 breeding does.

This research finding provides significant contributions to the U.S. meat goat industry. The increasing returns to scale finding suggests that the U.S. meat goat industry would benefit from significant increases in farm size. The U.S. Census results suggest the average meat goat farm includes 21 goats; our results show the size of operation that is scale efficient is 60 goats. Furthermore, in the Southeast, scope economies in meat goat production suggest diversification results in decrease total cost.

CHAPTER 1: INTRODUCTION

Goat production is an important livestock industry throughout the world, especially in developing countries, and goat meat is the most heavily consumed red meat in the world (Agricultural Alternatives, 2000). Moreover, meat goats are an important income source and food for rural populations in developing countries. These countries produced approximately 97 percent of the world's total goat meat in 2008 (FAOSTAT, 2008).

Since the early 1990s, the U.S. has developed a strong interest in meat goat production (Spencer, 2008). Since then, meat goat production has spread over all of the U.S. states, but the majority of the meat goat population is located in the Southeast, with Texas having the largest meat goat production (Figure 1). The Southeast region is well suited to producing goats because of extended grazing periods for meat goat production. This extended grazing period gives southeastern meat goat producers the opportunity to pasture goats year-round, decreasing meat goat producers' dependence on concentrated feedstuffs and adding value to goats with less expensive inputs compared to other regions. In some meat goat production regions or states, it is not possible to graze year-round, thus such regions depend on the use of conserved or stockpiled forages during a few months of the year. The Southeast meat goat production advantage is its more amenable weather, considerably longer grazing season, lower need for supplemental feed, and simpler and cheaper goat housing (Singh-Knights et al., 2005).

The attractiveness of goat production from an economic perspective is that it can complement other livestock production such as cattle, sheep and others on marginal grazing pasture land. Goat production is economically valuable because goats efficiently convert low-quality forage including brush and other less desirable plants into quality lean meat and other products, requiring less of other feed sources such as corn and other processed feed (Singh-

Knights et al., 2005). Moreover, meat goats can be produced with a small amount of grazing land and limited resources.
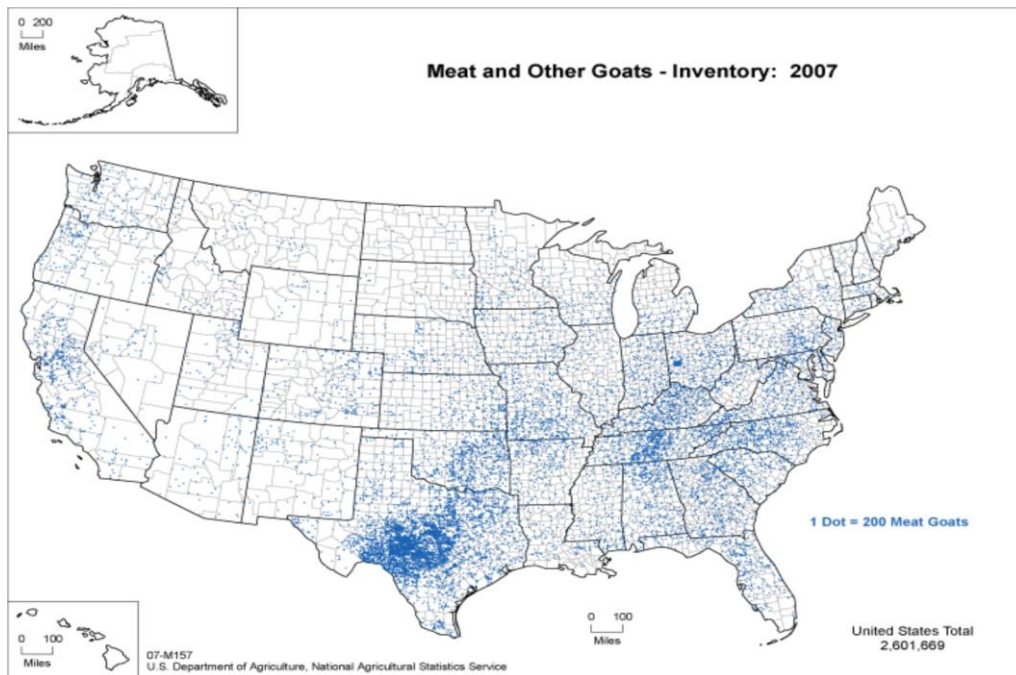
Figure 1. Distribution of Meat and Other Goats in the U.S.; Source: USDA APHIS 2011

1.1. The US Meat Goat Industry

In recent decades, the meat goat industry has been one of the fastest growing livestock industries in the U.S. (USDA/APHIS, 2012). A change in U.S. population demographics has led to increased demand for goat meat. During the last decade, the U.S. immigrant population increased significantly. Fourteen million new immigrants came to the U.S. between 2000 and 2010 (American Community Survey, 2010). Most of the immigrants were from developing countries and regions such as the Middle East, Africa, Asia, and the Caribbean Islands, and most of them consume lean goat meat. Since ethnic and faith-based consumers in the U.S. have increased significantly, these factors have been major determinants in increasing goat meat production (Solaiman, 2007). Growth of the goat industry will likely continue with changes in ethnicity in the U.S. population. Goats became popular throughout the world because of their

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small size. A small herd of meat goats can be produced on 10 to 15 acres of pastureland, so they can fit into more than 90 percent of U.S. farmsteads (Solaiman, 2007). Goats can also enhance small farm diversification and profitability (Solaiman, 2007).

Several organizations and associations were organized to stimulate meat goat production and meet the increasingly growing demand for goat meat in the U.S. In 1992, the American Meat Goat Association was formed to promote meat goats as a sustainable long-term income source in agricultural production. As a unique meat goat breed, South African Boer goats were brought into the United States in 1993 and the same year, the American Boer Goat Association was organized. In addition, the International Boer Goat Association and the U.S. Boer Goat Association were formed to enhance U.S. meat goat industry growth. Moreover, repealing of the Wool Act of 1954 in 1993 was a significant sign of meat goat production growth. Production of goats for hair, cashmere, or mohair declined substantially after removing the USDA's subsidies for the wool and mohair incentive programs in 1995. Many goat fiber or hair producers did not leave the goat industry but instead switched to producing meat goats (USDA/APHIS, 2004). Due to the loss of USDA subsidies for the fiber goat industry, Angora goat numbers declined substantially while meat goat numbers grew extensively (Figure 2).

One of the interesting factors facilitating the expansion of the meat goat production sector in the U.S., particularly within the Southeast, was financial settlements resulting from class action lawsuits against the U.S. tobacco industry (Spencer, 2008). Many tobacco producers in the Southeast, especially in KY, NC, SC, VA, and TN, had begun switching to meat goat production as financial resources were designated to pursue alternative forms of agricultural production (Spencer, 2008). These producers anticipated meat goat production as an economically viable enterprise for agricultural producers with limited financial and land resources.
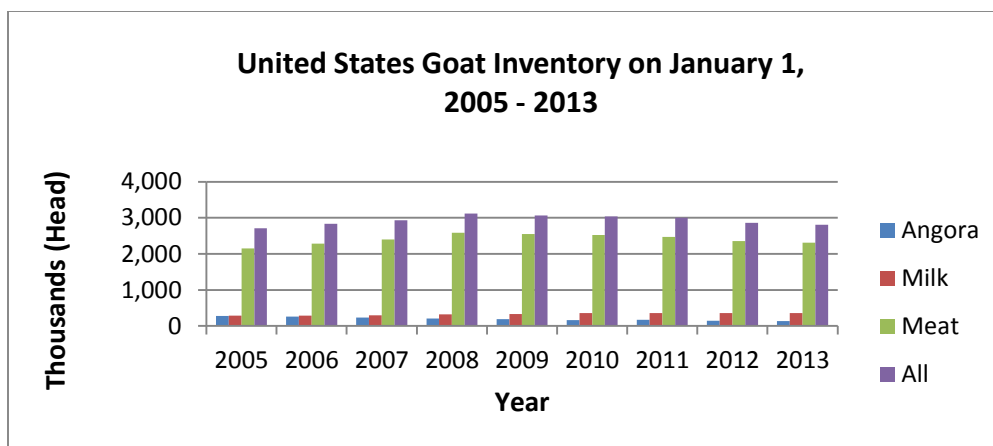
Figure 2. U.S. Goat Inventory; Source: USDA, NASS 2005 – 2013

In the U.S., meat goat numbers are lower than those for other livestock. The U.S. cattle inventory was 89,299,600 head on January 1, 2013; the hogs and pigs inventory was 65,911,000 head on March 1, 2013; and the all sheep and lambs inventory was 5,335,000 head on January 1, 2013 (USDA NASS, 2013). The all goats and kids (including Angora goats, milk goats, and meat and other goats) inventory in the U.S. was 2,811,000 on January 1, 2013. However, meat goat production has been the fastest growing livestock sector. The U.S. inventory for all goats, angora goats, milk goats, and meat goats from 2005 to 2013 is shown in Figure 2. Between 2005 and 2008, the number of meat goats increased by 20 percent or 440 thousand head. Meat goat inventory reached its largest numbers at 2.59 million head in 2008. Since 2008, meat goat production has been declining by an average of 2.2 percent per year. One of the reasonable explanations for this decline is the financial crisis of 2007-2008 and its impact on livestock production. The meat goat inventory included a total of 2.3 million head in 2013, having increased by almost 8 percent compared to 2005. However, Angora goat production has decreased gradually since the termination of subsidies for the wool and mohair incentive program in 1995. Angora goat production has decreased by more than 50 percent from 2005 to 2013.

One of the indicators of meat goat production growth is the number of federally slaughtered goats. Figures 3 and 4 show U.S. federally inspected goat slaughter for the periods of 1978-1997 and 2006-2012, respectively. As Figure 3 shows, the number of goats slaughtered increased steadily from a total of 97,300 head in 1980 to a total of 394,835 head in 1997. The number of federally-inspected goats slaughtered increased by 306 percent or more than quadrupled over that period. This meat goat production increase made the meat goat industry the fastest growing U.S. livestock industry.
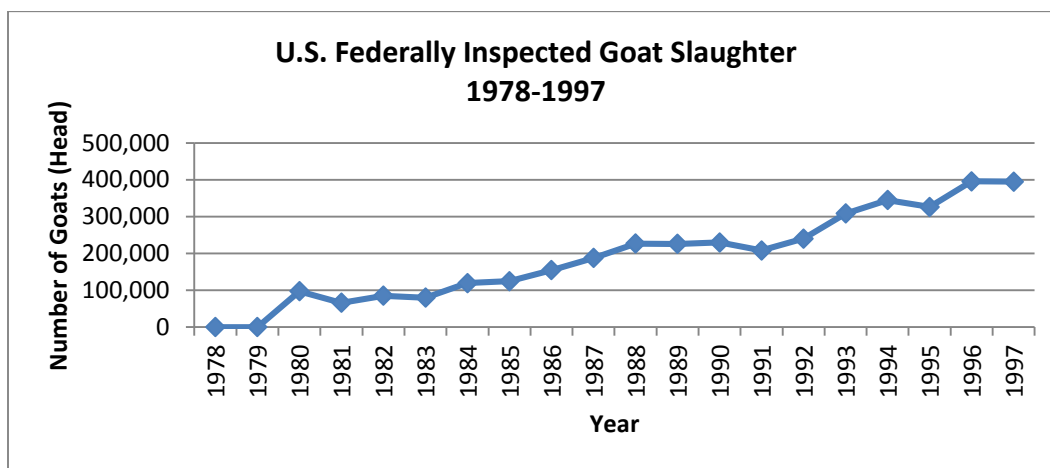
Figure 3. Actual Number of Goats Slaughtered under Federal Inspection from 1978-1997
Source: USDA, NASS, Livestock Slaughter 1978-1997

The number of meat goats slaughtered under federal inspection reached its highest point in 2008, at a total of 670.7 thousand head (Figure 4). The number of goats slaughtered declined from a total of 659.3 thousand head in 2009 to total of 557.9 thousand head in 2012. The average decrease was about 5.3 percent for that period of time. One of the explanations for this decline is the financial crisis of 2007-2008 in the U.S. The decline was also affected by the 2008-2012 U.S. droughts. Imports of goat meat increased over this period (Figure 5).

As seen Figure 5, U.S. goat meat imports increased starting in 1988 (FAOSTAT 1963-2011). This was the result of increased demand for goat meat in the U.S. The U.S. was a net exporter of goat meat until the 1990s, and goat meat production increased 2.5 times that of the

U.S. Federally Inspected Goat Slaughter 2006-2012
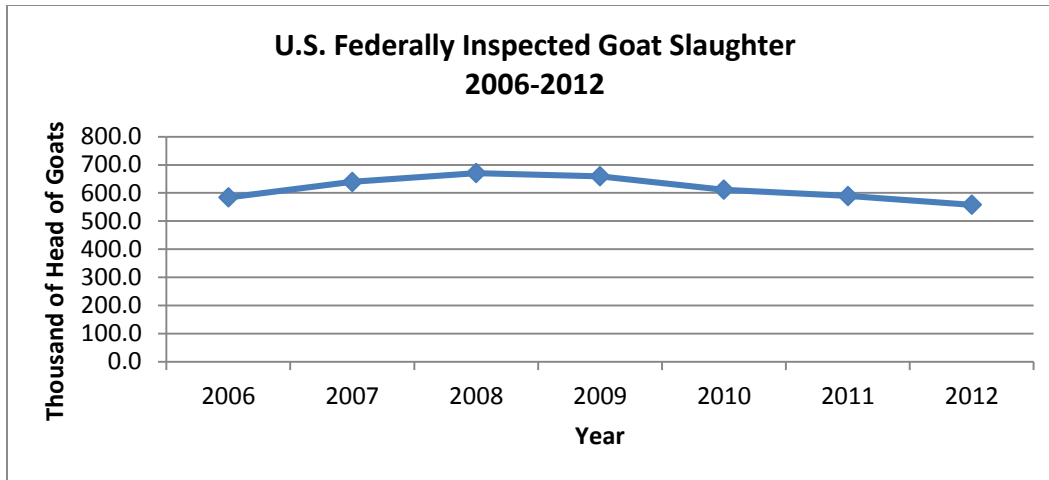
Figure 4. Actual Number of Goats Slaughtered under Federal Inspection from 2006-2012
Source: USDA, NASS, Livestock Slaughter 2006-2012

United States Goat Meat Imports
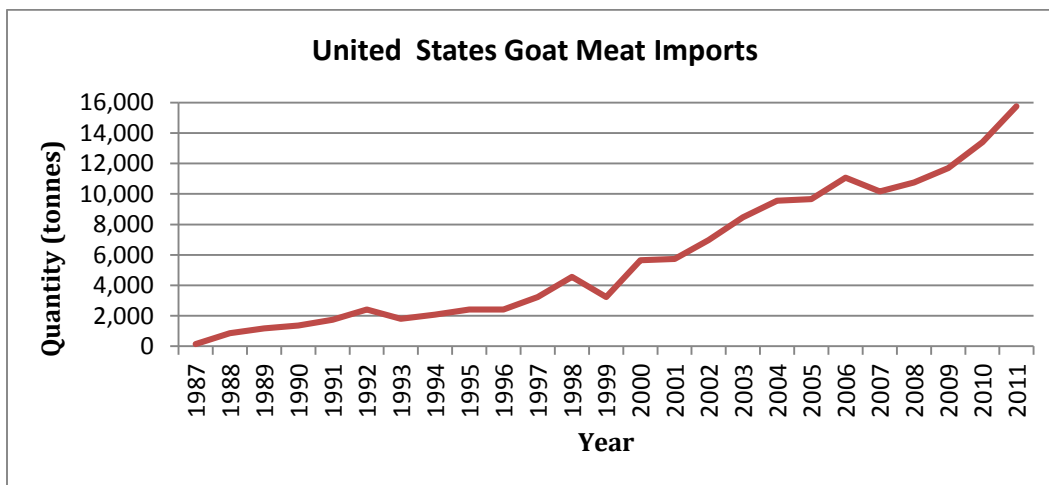
Figure 5. U.S. Goat Meat Import Quantities in Tonnes; Source: FAOSTAT 1963 – 2011

export amount of goat meat of 1990 starting in 1991 (FAOSTAT 1989-2001). This was an economic indicator for under-production of meat goat in the U.S. to meet consumer demand. The main goat meat exporter country to the U.S. is Australia. Its exports of goat meat to the U.S. accounted for nearly 97 percent of the total U.S. goat meat imports in 2012 (USDA Foreign Agricultural Service/Bureau of Census).

1.2. Problem Statement: Why the U.S. Meat Goat Industry?

Average U.S. goat herd sizes were 27.7 and 20.4 per farm for 2002 and 2012, respectively, and the number of all goat farms increased by about 40 percent from 2002 to 2012

(Table 1). As Table 1 shows, the biggest percentage change was in Angora goat farms compared

with milk goats and meat goats, 87 percent, 32 percent and 35 percent, respectively. However,

the average size of Angora goat operations declined by 49 percent versus 6 and 42 percent

increases in numbers of meat goats and milk goats, respectively (Table 1).

Table 1. Numbers of U.S. farms with goat products

Items	2012		2002		Percent Change in Farms	Percent Change in Operation Size
	Farms	Numbers	Farms	Numbers		
All goats	128,456	2,621,514	91,462	2,530,466	40.4	3.6
Angora goats	9,479	154,746	5,075	300,753	86.8	-48.5
Milk goats and kids	29,570	413,540	22,389	290,789	32.1	42.2
Meat goats and other goats and kids	100,910	2,053,228	74,980	1,938,924	34.6	5.9

Source: USDA, NASS, 2012 Census of Agriculture

The first and only comprehensive study of the structure of the U.S. goat industry we are

aware of was conducted by the USDA's National Animal Health Monitoring System in 2009.

That study had the first nationally representative information on the animal health and

management practices used in the U.S. goat industry. It found that the majority of U.S.

operations with 10 or more goats raised goats for meat, with lower percentages raising goats for

milk or fiber (USDA, Goat 2009). According to the 2007 USDA Census of Agriculture, about

76.6 percent and 78.3 percent of all goats in the U.S. were raised for meat in 2002 and 2012,

respectively. The percentage of all goats raised for meat showed an increasing rate, but for

angora, the percentage showed a slightly decreasing rate (Table 1). Therefore, meat goat

production has become a major alternative livestock industry in the U.S.

Despite the growth of the meat goat industry, little is known about meat goat production

economics. Information is needed concerning the drivers of production efficiency, optimum size

of operation, and scope economies in the industry.

1.3. Justification

In agricultural economics, the farm enterprise is a production component of the diversified farm business or the whole farm, producing a specific product. Production economists are interested in analyzing an enterprise's economic performance measures and the enterprise's relationship with other enterprises within the diversified-farm production system. A complex production system may arise where an output of one enterprise is an input to another enterprise. For example, hay as a farm output might be an input for the other livestock enterprises. The diversified farm business includes all activities of the production process added together. Diversified farm advantages are: 1) they may more effectively utilize labor, especially during the winter; 2) they may utilize capital more effectively, especially machinery and equipment; 3) the livestock enterprise of the diversified farm business may utilize crop residue or wheat pasture with little or no loss of crop revenue (Langemeier, 2011), and (4) diversification can serve as a risk management strategy. Moreover, the use of crop residue and the aftermath or wheat pasture could lower both livestock and crop enterprise total costs (Langemeier, 2011). A diversified farm may also include off-farm activities. Off-farm income can be important for enterprises to offset the income shortfalls of farm production.

Comparing productivity, cost and returns of farm production is of fundamental interest for production economists and the clientele they serve. Costs and returns estimation for beef cattle in Louisiana has shown that some cow-calf producers can receive returns above direct cash expenses (Boucher and Gillespie, 2010). However, cow-calf producers often do not cover total specified expenses (Boucher and Gillespie, 2010). On the other hand, goat production has not historically been a major economic contributor to U.S. agricultural production. Therefore, there has been little significant or noteworthy research on productivity (efficiency, profitability, etc.)

of the U.S. goat industry. There have, however, been a number of studies addressing goat nutrition, reproduction or genetics (Getz and Silcox, 2010).

This study focuses on efficiency analyses of U.S. goat meat production. Results and conclusions derived from this research will provide goat producers with knowledge of key factors needing consideration for efficiency and development of the meat goat industry in the U.S. In addition to this, there are benefits to understanding efficiency drivers for potential goat meat producers when they are considering whether to enter the industry.

1.4. Purpose and Objectives

This study attempts to determine the economic and other factors influencing the development and competitiveness of the U.S. meat goat industry through the analysis of technical efficiency. The specific objectives of the study include:

1. Determine the important economic factors influencing technical efficiency;

2. Determine the extent of economies of scale and scope for U.S. meat goat farms.

1.5 Organization of the Study

This dissertation contains five chapters. Review of the relevant literature for this study is given in Chapter Two. Collection of the mail survey data and the research methodology for this study are presented in Chapter Three. Moreover, implementation of survey data and estimation methods of production efficiencies, particularly input distance function (IDF) estimation, are also discussed in this Chapter. Descriptive statistics, IDF analysis, and Monte Carlo (MC) simulation results are discussed in Chapter Four. Finally, the summary of the research findings and conclusions along with further suggestions for research are given in Chapter Five.

CHAPTER 2: REVIEW OF LITERATURE

There has been a long history of production efficiency analysis in the agricultural economics profession since the seminal study of Farrell (1957) on a methodology for measuring efficiency. Throughout the years, a number of studies have estimated production efficiency of various types of farms: Battese and Coelli (1988, for dairy farms); Heshmati and Kumbhakar (1997, for crop farms); Sharma et al. (1999, for hog farms); and Alvarez and Arias (2003, for dairy farms). Most of these studies have focused on estimating farm technical efficiency. These studies used stochastic frontier production functions or data envelopment analysis for panel data, in which technical efficiencies of farms would vary over time. Allocative, scale and technical efficiencies of beef cow farms (Featherstone et al., 1997) were estimated using a non-parametric approach.

Over the past few decades, structural and technological changes have taken place in the U.S. agricultural sector. In particular, the increased tendency to move toward larger farms has been of concern with implications for survivability of small farms in a competitive market. A few studies have examined the economic performance of U.S. Corn Belt farms (Morrison-Paul et al., 2004; Morrison-Paul and Nehring, 2005) and explored the potential competitiveness of small versus large farms. Overall, large farms were shown to have cost advantages over small farms. These studies estimated output and input distance functions using stochastic frontier techniques.

Though limited research has addressed goat farm efficiency, several studies have examined beef cow industry production performance measures. It can be argued that beef cow-calf farms are the most similar to goat farms since both rely primarily on grazing as a feed source. Studies have estimated the technical, allocative and scale efficiencies of cow-calf farms using a nonparametric linear programming-based approach, data envelopment analysis

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(Featherstone et al., 1997; Rakipova, Gillespie and Franke, 2003). These studies used Tobit models to examine the relationship between the estimated efficiency measures and farm characteristics. Larger beef cow farms were more technically efficient than smaller beef cow farms and herd sizes of farms up to 48 beef cows exhibited substantial economies of scale (Featherstone et al., 1997).

Rakipova, Gillespie and Franke (2003) focused on the discussion of technical efficiency and the effect of cow-calf farm characteristics and management practices on technical efficiency. Two studies have examined European beef cattle farm technical efficiency and profitability, focusing on the possible impact of the Common Agricultural Policy (Iraizoz et al., 2005; Trestini, 2006). Both used stochastic production frontier models. Government subsidies were found to have counteracting effects, reducing input costs and having a negative effect on technical efficiency (Iraizoz et al., 2005).

A recent study estimated economic performance measures and technical efficiencies of U.S. cow-calf farms (Nehring et al., 2009). Adoption of new regression techniques allowed them to relate multiple outputs to multiple inputs in a single equation to measure technical and scale efficiencies. This study employed the 2007 phase III Agricultural Resource Management Survey (ARMS) data. Large farms were significantly more scale efficient and technically efficient than small cow-calf operations. However, small cow-calf farms could be competitive as long as producers had substantial off-farm income.

Most studies have used Cobb-Douglas functional forms to estimate production functions. Some of the recent studies have employed the stochastic cost frontier which was derived from the stochastic production frontier to estimate cow-calf farm producer economic performance measures (e.g. Samarajeewa et al., 2012). They used the Cobb-Douglas functional form to

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measure relative efficiencies of cow-calf farms in Alberta. They used panel data for a sample of 333 Alberta cow-calf farms and found average technical, allocative, and economic efficiencies of 83 percent, 78 percent, and 67 percent, respectively. Tobit regression analysis was used to estimate technical inefficiency parameters of cow-calf farms.

Few studies have investigated goat production efficiency and its productivity and profitability. Moreover, limited work has addressed meat goat production efficiency in the U.S. Alex et al. (2013) conducted research on returns and determinants of technical efficiency in small-scale Malabari goat production units in Kerala, India. They used a stochastic frontier production function to measure technical efficiency and its determinants for small-scale goat production units. One-hundred goat farmers were selected using a multistage random sample for the study. They found that feed constituted the major production cost. Goat farm levels of technical efficiency ranged between 0.34 and 0.97 with a mean value of 0.88. The authors suggested that there were still opportunities for increasing productivity and income of goat farmers by increasing efficiency. They found that farm size and location were the important factors related to technical efficiency. However, they found no significant relationship between technical efficiency and producer gender, education, land size, or family size. The study also confirmed that a greater number of adult animals reduced goat farm technical efficiency as well as returns per animal. They argued that raising one or two goats without much labor involvement and cost would provide an additional source of income for rural people, particularly to women. This study concluded that the scope of commercialization in goat rearing is limited given the prevailing socio-economic scenario of Kerala state.

Ogunniyi (2010) studied the economic efficiency of goat production in the Ogbomoso agricultural zone of Oyo State, Nigeria. The study used cross-sectional survey data sampled from

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80 goat farmers. A log transformed Cobb-Douglas frontier production function was used to investigate goat production efficiency. The estimated parameters of labor and feed were statistically significant (labor and feed had positive and negative signs, respectively). The study found that feed frequency, education, years of establishment, and number of head were the main factors affecting the economic inefficiency of goat production. The mean economic efficiency was 0.60. The study concluded that there was scope for increasing goat production economic efficiency by about 40%.

Hidayat (2007) conducted an analysis of integrated goat farms in Banyumas, Indonesia. This research found that goat farming had a significant contribution in an integrated farming system (goat and paddy; goat and fish; and goat, paddy and fish), and these integrated production systems could be economically efficient. The study also found that the number of goats owned, land, urea application, manpower, feed, and breed were all factors affecting production level. The research concluded that goat farming could be an alternative enterprise to be developed in integrated farming operations and could be combined with other farming activities.

Zaibet et al. (2004) investigated socio-economic changes in a local community of Jabal Akhdar in Oman and assessed their impact on the economic performance of goat production using the concept of technical efficiency. Socio-economic changes have had a direct impact on animal production in most oil-exporting countries in the Arabian Gulf. In Oman, self-sufficiency in goat meat had declined from 24 percent in 1995 to 20.5 percent in 2000. They conducted research on economic performance of goat production for a sample of 43 farmers. Data were collected through a survey questionnaire of randomly chosen farmers in the Jabal Akhdar region. Farmers were asked about cash expenses, returns, and characteristics of farm and household in terms of family and hired labor, non-farm off-farm income, farm size, flock size, irrigation,

source of irrigation, and home consumption. The study used data envelopment analysis (DEA) to derive technical efficiency measures. To compute return-to-scale (RTS) intervals, they used the Banker-Thrall (Banker and Thrall, 1992) model. The study also used the two-stage ordinary least squares method to determine technical efficiency components. They found that feeding cost and off-farm income were influential factors for the technical efficiency of goat farmers. However, they found that farm size, flock size, and family labor were not influential in predicting the output for technically efficient farmers. They also found that goat production showed decreasing return-to-scale. They summarized the findings as follows: (a) off-farm income is the major source of income for goat farms; (b) relatively large flock sizes are maintained but declining grazing is compensated by increasing purchases of feedstuffs; and (c) important inefficiencies exist in the use of resources.

A number of studies have used input distance functions (IDF) to assess the efficiency of farms. Karagiannis et al. (2002) was based on an unbalanced panel data sample of 121 UK livestock farms for 1983-92. The study was to estimate total factor productivity (TFP) changes including technical change, change in technical and allocative efficiency, and scale economies using IDF approaches. A more complete decomposition of output growth can be achieved from IDF analysis. The study found that output growth was affected by changes in the degree of technical efficiency over time. During the period 1983-92, technical inefficiency tended to increase over time. The average technical efficiency was 82.8 % during the period 1983-92. This means that, on average, total cost could be decreased by 17.2 % without changing the total output, production technology, and input usage on UK livestock farms. Mean allocative efficiency was 53.9% for the period, which implied that UK livestock farms achieved a relatively poor allocation of existing resources. Average productive efficiency was 44.4%, implying that

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significant cost savings could be achieved by improving technical and allocative efficiencies. Parameter estimates of the study indicated that annual technical progress on average for UK livestock production was 0.2%. The average annual output growth rate was 1.9%. However, this growth was mainly the result of increased sheep and wool production. The study found that most of the output growth in livestock production was due to increases in inputs. It was found that substantial output growth was still possible by improving TFP. The scale effect was positive for the UK livestock farms; they exhibited increasing return to scale. The study concluded that improvement in technical and allocative efficiencies would provide greater potential for the improvement of farm returns.

Coelli et al. (2003) described how one can measure technical and allocative efficiency relative to a stochastic IDF. They used survey data on private and cooperative Indian dairy processing plants to illustrate this method. The raw material was the major input cost in the total output operations, with an estimated raw material coefficient of 0.68. The estimated coefficients for labor, capital, and other inputs were 0.11, 0.05, and 0.17, respectively. The study found increasing returns to scale in the dairy industry and technical efficiency had decreased significantly over the five-year period (1992/93 – 1996/97). The average technical, allocative, and cost efficiency scores suggested that private plants were not as cost-efficient as their cooperative counterparts. The study concluded that the introduction of reform to encourage the entrance of new private sector firms did not have the expected positive effect upon cost efficiency in the industry. However, the main contribution of this paper was methodological with proposing a new IDF approach to the calculation and decomposition of cost efficiency.

Morrison-Paul et al. (2004) used IDF analysis to measure and evaluate factors underlying scale economies and efficiency of U.S. Corn Belt farms for 1996-2001. The IDF analysis in this

study revealed that small family farms were generally less efficient than large farms in terms of both their scale of operations and technical aspects of production. Farms had statistically higher technical efficiency in the Heartland and the Northern Crescent regions. Education had little impact on technical efficiency. Age was associated with greater potentially exploitable scale economy. Debt to equity (debt/equity) ratio level was associated with lower scale economies. Overall, the conclusion was that large farms had gained a cost advantage by taking advantage of scale and diversification economies. There was a concern of small farm survivability in increasing competitiveness of large farms.

There are significant gaps in the empirical analysis of U.S. meat goat production efficiency in the current literature. However, there have been some empirical analyses and a significant number of the scholarly articles (Fisher et al., 2009; Ibrahim et al., 2008, Knight et al., 2006; Nelson et al., 2004; Worley et al., 2004; Mclean-Meyinsse 2003) have addressed consumer preferences for goat meat in the U.S. In general, these previous studies have examined the marketing side of meat goat production in the U.S.

This chapter has presented a literature review of relevant studies on production efficiency including technical and scale efficiencies, scale and scope economies. These economic performance measures have been used extensively by researchers to estimate efficiency measures of farms. A significant number of studies have estimated production efficiency of various types of farms including beef cow-calf, dairy, crop, hog, poultry, sheep, etc. However, few if any studies have explored goat production efficiency in the U.S.

CHAPTER 3: DATA AND METHODOLOGY

3.1. Data

In order to meet the objectives of the study, a nationwide mail survey of U.S. meat goat producers was conducted during Spring, 2013(Appendix A). Cost and returns data were collected from these farms. The first mailing of the four-page questionnaire, sent January 28, 2013, on meat goat farm production returns and expenses for 2011 included a cover letter stating the rationale for conducting the research on the goat industry with an emphasis on the strict confidentiality of all information and a postage-paid return envelope. The second mailing sent out three weeks later to the meat goat farmers who had not responded included a new cover letter, the survey questionnaire, and another postage-paid return envelope.

This survey was a follow-up to a first survey that had focused on the marketing, technology, farmer attitudes, and farm and farmer characteristics of U.S. goat production. The first survey was also conducted nationally by mail during late Summer and early Fall, 2012. The first survey population was selected from nationwide online meat goat farm listings, with a total of 1,600 meat goat producer addresses collected from an extensive internet search. The survey was designed according to Dillman's (2007) Tailored Design Method. From the first survey, a total of 584 completed responses were received. An additional 190 producers indicated they did not produce meat goats in 2011 and a total of 52 undelivered surveys were returned to us. Thus, the adjusted response rate was 43 percent.

The reasons for the follow-up cost and returns survey were to estimate U.S. meat goat farm efficiency. The study also used demographics and farm characteristics from the first meat goat survey. The last question in the first survey asked meat goat farmers about their willingness to fill out the follow-up survey on cost and returns of meat goat production in 2011. A total of

435 meat goat farmers agreed to fill out the follow-up survey questionnaire. A total of 142 responses to the follow-up survey were received. Of these, 107 meat goat farmers completed the survey questionnaire, 17 answered all but a few questions, 5 farmers answered only a few questions, 10 farmers returned the survey indicating they did not produce meat goats during 2011, one farmer was a sheep producer, and two surveys were undeliverable. Farmers who did not produce meat goats in 2011 and undeliverable surveys were removed from the total survey population. We also removed five farmers' survey responses from the total survey population because the responses were not useful for our research analysis due to too few of the questions being answered. A multiple imputation method was used for the 17 survey responses that were missing a few data points to impute missing information and fully complete those responses. The multiple imputation method is described in the Section 3.1.2 of this chapter. The follow-up survey had an effective return of rate 29.7 percent after adjusting for removed responses.

3.1.1 Mail Survey

A four-page survey questionnaire including an attractive cover on the first page was designed similarly to the questionnaire for USDA's 2008 Agricultural Resource Management Survey (ARMS). The survey was divided into 3 sections (Appendix A). In the first section, meat goat farmers were asked about the farm's total revenue from sales of crop and/or livestock commodities in total dollar value after subtracting marketing expenses in 2011. See the survey in Appendix A. This total revenue section included eight questions. Meat goat producers were asked to report their annual return from sales of field crops, hay and silage, vegetables, fruit, and other crops in 2011. Respondents were also asked to report their annual revenue from sales of animals and animal products other than meat goats, goat meat, and beef cattle. There was a separate question on total revenue from the sales of cattle and calves. Since this study focused on

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meat goat farmers' production efficiency, producers were asked to assess separately total revenue from the sales of meat goats (excluding breeding stock), meat goat breeding stock, and goat meat.

In the second section, farmers were asked to report their expenses for marketing and storage in total dollar value incurred in 2011. There was a separate question on marketing and storage expenses specifically for the meat goat enterprise.

The third section covered operating expenses in total dollar value for the meat goat farm operation incurred in 2011. This section comprised a total of 37 questions including sub-questions specifically for the meat goat enterprise. Meat goat farmers were asked to report their expenses for seeds, sets, plants, seed cleaning and treatments, transplants, trees, nursery stock, nutrients, fertilizer, lime, soil conditioners, bio-controls, and agricultural chemicals for crops, livestock, poultry, and general farm use. Producers were asked to evaluate their expenses on purchases of breeding stock for meat goats, other meat goats, and beef and dairy cattle, hogs, pigs, sheep, dairy goats, goats for mohair, chickens, turkeys, lambs, bees, brooder fish, fingerlings, etc.

One of the major production expenditures for most livestock operations is feed. Therefore, meat goat producers were asked to report their expenditures for purchased feed and/or silage for livestock, dairy, poultry, and/or aquaculture. They were then asked to report the portion of the reported feed expenditure specifically allocated to the meat goat enterprise. Meat goat producers were asked to evaluate their expenses for bedding and litter, medical supplies, veterinary, and custom services for livestock. The survey asked producers to report the portions of these expenses for the meat goat enterprise. Producers were asked to report the variable expenses for all fuels, oils, lubricants, electricity, and maintenance and repair for the upkeep of

all farm buildings, land improvements, and all other farm/ranch improvements for the farm business and the portion of these expenditures allocated to the meat goat enterprise. In addition to the above variable expenses, producers were asked to report their expenses for all other utilities and water for irrigation, farm supplies, marketing containers, hand tools, farm shop power equipment, and repairs, parts, and accessories for motor vehicles, machinery, and farm equipment.

The questionnaire also asked meat goat farmers to evaluate their fixed expenses for farm production. They were asked to report their insurance expenses for the farm business; interest and fees paid on debts for the operation; property taxes paid on farm real estate; livestock, machinery, and other farm production items; expenses for renting or leasing of tractors, farm vehicles, equipment, or storage structures; and farm vehicle and licensing fees for the farm business. In addition to these fixed expenses, producers were asked to report their expenditures on renting or leasing of land for the farm operation and depreciation expenses claimed by their operation in 2011 for all capital assets. The survey also asked respondents to allocate the portion of each of these expenses for the enterprise.

A number of questions were asked about labor expenses for the meat goat farm and enterprise. Producers were asked to assess their expenditure on cash wages paid to hired farm and ranch labor plus payroll taxes and benefits, custom work performed by machines and labor hired as a unit, and the cash value of feed, farm commodities, fuel, housing, meals, utilities, vehicles for personal use, and other non-cash payment for farm work. Respondents were also asked to report the portion of these labor expenses for the meat goat enterprise. Expenses on professional or farm management services such as record-keeping, accounting, tax and business planning, farm product advice, conservation practices, etc. were also to be reported.

One of the common difficulties in using survey data is incomplete or missing information; this study is no exception. Therefore, we employ a statistical technique known as multiple imputation methodology to impute the missing information in the survey data.

3.1.2 Multiple Imputation for Missing Data

Missing information occurs frequently in survey data. It has been an issue in research analysis for a number of reasons. Using surveys, respondents may decide not to answer certain questions, unintentionally skip questions, or they may not have the requested information available at hand. These incomplete data may be analyzed inappropriately by researchers and have been problematic in research analysis for a number of reasons. According to Rubin (1987) and Schafer (1997), missing data may lead to biased estimates and reduce the efficiency of regression estimates. Most statistical software procedures rely on complete-data methods of analysis (Rubin, 1987; Allison, 2000) and exclude all missing data on any of the variables from computation. This procedure is known as listwise deletion. Excluding all cases including missing data leads to two serious problems: analytic power may be significantly reduced (Allison, 2000) and nonresponse bias (Barnard and Meng, 1999) may result. According to Tabachnick and Fidell (1999), when respondents who do not answer a particular question differ from those who do respond, a systematic pattern of bias characterizes the missing data. There are different reasons that non-respondents may omit certain questions and researchers may never know the reasons.

Missing information is identified as missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR). MCAR occurs when the probability of missing information on one variable is not related to the value of the variable itself or to other variable values in the data set (Allison, 2000). Missing data is MAR if the probability of missing information for one variable is not related to the variable itself but may be related to other

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variable values in the data set (Allison, 2000). MNAR occurs when the probability of missing information for one variable is related to the value of the variable itself and to values of other variables in the data set (Allison, 2000). Various methods exist to handle missing data. Listwise deletion, pairwise deletion, weighting techniques, mean imputation, regression imputation, stochastic imputation, single imputation, and multiple imputations have been used for handling missing information in a variety of research areas over the last several decades. However, the multiple imputation (MI) technique has gained increasing popularity over the last two decades. The MI method is used to handle the missing information in this study.

The MI technique was developed by Rubin (1987) to overcome the shortcomings of other imputation methods. These problems have been discussed extensively by researchers (Rubin, 1987; Schafer, 1997; Little and Rubin, 2002). For example, single imputation imputes one value for each missing value and the one imputed value cannot itself represent any uncertainty about which value to impute (Rubin, 1987). A major problem of single imputation is that it underestimates uncertainty because it treats imputed values just like observed values (Rubin, 1987). MI methods, either univariate (uses noniterative techniques) or multivariate (uses an iterative Markov Chain Monte Carlo (MCMC) technique) are based on simulation and involve drawing values of the parameters from the posterior predictive distribution (Rubin, 1987; Schafer, 1997). MI consists of three steps: imputation, completed-data analysis, and pooling steps. In the imputation step, M imputations (completed datasets) are generated using a chosen imputation model. In the completed-data analysis, the desired analysis is performed separately on each imputation m = 1... M. In the pooling step, the results obtained from the M completed-data analysis are combined into single MI-based estimation results. For more details about MI and imputation modeling, see Rubin (1996), Schafer (1997), Schafer and Olsen (1998), Allison

(2001), Schafer and Graham (2002), Kenward and Carpenter (2007), Graham (2009), and White, Royston, and Wood (2011), among others.

In this meat goat production costs and returns survey, the following survey questions had missing information (Table 2). Depreciation expense questions had 13 missing values for both the whole farm and goat enterprise. Electricity expense questions had 4 and 5 missing values for the whole farm and goat enterprise, respectively. All fuels including oil and lubricant expense questions had 4 and 5 missing values for whole farm and goat enterprise, respectively. Purchases of breeding stock for meat goats, purchases of other meat goats, purchases of all other livestock, and interest and fees paid on debts questions had 2 missing values each. The maintenance and repairs for the upkeep of all farm buildings including land improvements and all other farm/ranch improvements question had one missing value each for the whole farm and goat enterprise. Finally, the all other utilities and water for irrigation question had one missing value.

Table 2. Missing Information in the Survey Questionnaire

Questions with Missing Information	Number with Missing Data	Percentage with Missing Data
1. Depreciation expense claimed by this operation in 2011 for all capital assets;	13	10.5
(a) How much of expense in (1) was claimed for the meat goat enterprise?	13	10.5
2. Electricity for the farm business;	4	3.2
(a) How much of expense in (2) was claimed for the meat goat enterprise?	5	4.0
3. All fuel, oils, and lubricants;	4	3.2
(a) How much of expense in (3) was claimed for the meat goat enterprise?	5	4.0
4. Purchases of breeding stock for meat goats	2	1.6
5. Purchases of other meat goats	2	1.6
6. Purchases of beef and dairy cattle, hogs, pigs, sheep, dairy goat, goat for mohair, chicken, turkeys, lambs, bees, brooder fish, fingerlings, etc.	2	1.6
7. Interest and fees paid on debts for the operation	2	1.6
8. All other utilities and water for irrigation	1	0.8
9. Maintenance and repair for the upkeep of all farm buildings, land improvement, and all other farm/ranch improvements	1	0.8
(a) How much of expense in (9) was claimed for the meat goat enterprise?	1	0.8

Source: U.S. Meat Goat Production Cost and Returns Survey

The percentages of missing information for the depreciation expense questions for the whole farm and meat goat enterprise were 10.5% each, having proportionately more missing information than the other questions in this survey (Table 2).

This study employs the truncated regression imputation method to fill in missing values of continuous variables listed in Table 2. The distribution of all the missing variables in this study is restricted from below: the variables in this survey should take zero or any positive continuous value. These variables cannot be negative values. Various statistical post-estimation diagnostics or procedures, for example likelihood-ratio tests, goodness-of-fit tests, etc. are not directly applicable to MI results. Therefore, the main descriptive statistics from some imputations were compared. Table 3 shows the results of the truncated imputation method summary statistics. The results generally look reasonable. The means of the observed values are similar to the means of the imputed values. The standard deviations of the completed values are smaller than those of the observed values.

Table 3. Summary Statistics of the Observed, Imputed, and Completed Data

Variable	Obs	Mean	Std. Dev.	Min	Max
Depreciation:					
Observed	111	3648.71	6982.92	0	44455.00
Imputed	13	3538.46	5530.39	0	20000.00
Completed	124	3637.15	6825.88	0	44455.00
Depreciation for Meat Goat Enterprise:					
Observed	111	2173.88	4951.03	0	32933.88
Imputed	13	2309.46	3557.95	0	13136.98
Completed	124	2209.07	4813.27	0	32933.88
Electricity:					
Observed	120	690.04	1236.68	0	9649.00
Imputed	4	782.12	808.61	56.47	1787.16
Completed	124	693.01	1223.05	0	9649.00
Electricity for Meat Goat Enterprise:					
Observed	119	318.70	449.18	0	2435.00
Imputed	5	312.93	51.20	226.73	358.82
Completed	124	318.46	440.05	0	2435.00
Fuel:					
Observed	120	1371.25	2264.92	0	10200.00
Imputed	4	1424.49	1955.80	103.26	4279.43
Completed	124	1376.20	2248.79	0	10200.00
Fuel for Meat Goat Enterprise:					
Observed	119	707.95	1502.90	0	1000.00
Imputed	5	733.90	1130.07	9.03	2654.93
Completed	124	708.99	1485.43	0	10000.00
Purchase of Meat Goat:					
Observed	122	254.20	1255.65	0	11000.00
Imputed	2	250.00	353.55	0	500.00
Completed	124	254.13	1245.81	0	11000.00

Table 3 Continued. Summary Statistics of the Observed, Imputed, and Completed Data

Variable	Obs	Mean	Std. Dev.	Min	Max
Purchase of Livestock:					
Observed	122	591.84	1898.77	0	14860.00
Imputed	2	576.15	302.64	246.78	905.52
Completed	124	585.75	1884.07	0	14860.00
Interest and Fees:					
Observed	122	1036.48	3306.57	0	25606.00
Imputed	2	1099.68	912.99	469.09	1730.28
Completed	124	1037.74	3280.62	0	25606.00
Utilities:					
Observed	123	398.47	790.31	0	4500.00
Imputed	1	379.00	-	379.00	379.00
Completed	124	397.68	787.13	0	4500.00
Maintenance:					
Observed	123	1201.90	2541.11	0	13443.00
Imputed	1	1291.00	-	0	1291.00
Completed	124	1204.30	2530.90	0	13443.00
Maintenance for Meat Goat Enterprise:					
Observed	123	949.35	2473.34	0	13443.00
Imputed	1	993.03	-	993.03	993.03
Completed	124	952.45	2463.50	0	13443.00

3.2 Parametric versus Nonparametric Estimation of Efficiency

Studies have used a variety of methods to evaluate the efficiency of farm production. Major components of efficiency analysis have been technical, allocative, scope, and scale efficiencies of firm production. After Farrell's (1957) seminal article, several techniques for the measurement of technical efficiency of production have been developed, and these techniques are mainly divided into two approaches: parametric and nonparametric. The nonparametric technique commonly known as data envelopment analysis (DEA) (Boles, 1966; Afriat, 1972; Charnes et al., 1978; Färe et al., 1989, 1994) and the parametric stochastic production frontier (SPF) (Aigner et al., 1977; Meeusen and J. van den Broeck, 1977) are used for estimating economic performance measures. Parametric efficiency analysis applies statistical and econometric methods to the specified functional forms (whether production, cost, or profit functions). Nonparametric DEA efficiency analysis measures the efficiency of decision making units of the firm using linear programming methods.

The main advantage of the parametric over the nonparametric approach is that the parametric method reveals the nature of the technology, various hypotheses and statistical inferences can be tested, and the characteristics of firm-specific efficiency measures can be readily measured using the model. However, the main weakness of the parametric approach is the need to impose an explicit parametric form on the underlying technology and the explicit distributional assumption for the inefficiency term (Coelli, 1995; Sharma et al., 1999).

The main advantage of the nonparametric approach is that it does not require the specification of a particular functional form for the technology and does not require imposing any distributional assumptions on firm-specific effects. However, the principal disadvantage of the nonparametric method is that when the calculation of shadow prices is desired, only a range of prices can be derived for the efficient firm. Other major disadvantages are that it can be extremely sensitive to variable selection and data errors (Coelli, 1995; Coelli and Perelman, 1999).

The relative performance of the parametric approach depends on the selected functional form. If the functional form closely approximates the underlying technology, then the parametric approach will generally outperform the nonparametric method (Coelli, 2003).

3.3 Estimation of Production Efficiencies: The Production Frontier Model

The estimation of production efficiency using frontier models has been conducted extensively in applied economics. The idea behind this approach is that the efficiency of production is the distance between the actual output level of the firm and the level it should obtain if it were efficient. The efficiency is characterized as the optimal production frontier or frontier function for a given combination of inputs. So the efficiency of the firm is obtained from

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its distance to the estimated frontier. A frontier function can be modeled by parametric or non-parametric approaches.

With the parametric approach, there exist two frontier models: stochastic and deterministic. In the deterministic frontier model, all observations lie below the production frontier. However, the stochastic frontier model allows for data noise around the production frontier. The general form of the frontier model is:

$$q_i = f(X_i; \beta) + \varepsilon_i \tag{1}$$

where for the stochastic frontier model $\varepsilon_i = v_i - u_i$ and for the deterministic frontier model $\varepsilon_i = -u_i$, q_i measures the quantity of output of the ith firm, X_i represents input quantities, and β is a vector of parameters. The random error v_i is independently and identically distributed as $N(0, \sigma_v^2)$ and also independent of u_i; and u_i represents non-negative random variables associated with technical inefficiency in production, independently and identically distributed as half-normal, $u \sim |N(0, \sigma^2 u)|$. The farm-specific technical efficiency u_i could be estimated by the conditional expectation of $exp(-u_i)$ (Jondrow et al., 1982).

We know that a production technology can be represented in many forms. Input and output distance functions are alternative forms, which are often used when there are multiple outputs. Specifically, this study uses an input distance function approach rather than an output distance function approach for the efficiency analysis. This is because farmers can generally manage and control input usage during the short run period but not output decisions (Morrison Paul et al., 2004). The characteristics of the input distance function and efficiency components including technical, scope and scale efficiencies are reviewed in the next sections.

3.4 Input Distance Function (IDF)

The IDF approach was developed by Shepard (1953) and its application to applied economics began with a number of studies (e.g., Färe et al., 1993; Lovell et al., 1994). The main

advantage of the IDF is that it allows for the possibility of specifying a multiple-input and -output technology when price information is not available or alternatively when price information is available but cost, profit or revenue function representations are precluded because of violations of the required behavioral assumptions (Coelli et al., 1999). The IDF's major role is duality to the cost frontier and it can be estimated econometrically to provide technical efficiency measures when firms use multiple inputs to produce multiple outputs (Kumbhakar et al., 2000).

To define the IDF, the study begins by defining the production technology of the firm using the input set of q which represents the set of all input vectors, $x \in R_+^K$, which can produce the output vector, $q \in R_+^M$. That is, $L(q) = \{x \in R_+^K : x$ can produce q $\}$.
The IDF may be proportionally expanded with the output vector held fixed. So the input distance function may be defined on the input set, $L(q)$, as a function of

$$D^I(x, q) = \max\{\lambda: \frac{x}{\lambda} \in L(q)\}, \tag{2}$$

where the input set $L(q)$ represents the set of all input vectors and $x \in R_+^K$, which can produce the output vector, $q \in R_+^M$.

$D^I(x, q)$ is non-decreasing, positively linearly homogeneous and concave in x, and increasing in q. The distance function, $D^I(x, q)$, will take a value which is greater than or equal to one if the input vector, x , is an element of the feasible input set, $L(q)$. That is, $D^I(x, q) \geq 1$ if $x \in L(q)$. Moreover, the distance function will take a value of one, $D^I(x, q) = 1$, if x is located within the inner boundary of the input set, $L(q)$.

3.4.1 Technical Efficiency (TE)

Input-oriented technical efficiency (Debreu, 1951; Farrell, 1957) measures the ability of the firm to minimize input in the production process of a given output vector. The input-oriented

measure of technical efficiency of the firm can be expressed in terms of the input-distance

function (Shephard, 1953) $D^I(x, q)$ (Coelli, 2005) as:

$$TE_I(q, x) = \frac{1}{D^I(x, q)} \quad and \quad D^I(x, q) = max\left\{\theta : \left(\frac{x}{\theta}\right) \in L(q)\right\}, \quad D^I(x, q) \geq 1 \tag{3}$$

where $L(q)$ is the input set, x is the input vector, and q is the output vector. $D^I(x, q)$ measures the

largest factor of proportionality by which the input vector can be reduced in order to achieve

technically efficient production (given the output vector). The firm is technically efficient if it is

on the frontier, in which case $TE = 1 \; or \; D^I(x, q) = 1$.

3.4.2 Scale Efficiency (SE)

The firm can be both technically and allocatively efficient, but the scale of operation may

not be optimal (Coelli et al., 2005). If the firm is producing under a constant returns-to-scale

(CRS) technology, then it is scale efficient. If the firm is using variable returns-to-scale

technology (VRS), then it may not be scale efficient. Variable returns-to-scale technology may

be divided into increasing and decreasing returns-to-scale technologies. Scale efficiency (Coelli,

2005) may be characterized as:

$$SE(x, q) = \{TE_{CRS}/TE_{VRS}\}. \tag{4}$$

where TE_{CRS} is the technical efficiency of the firm that is the distance from the observed data

point to the CRS technology. TE_{VRS} is the technical efficiency of the firm that is the distance

from the observed data point to the VRS technology. Scale efficiency also can be defined in

terms of input-oriented measures of scale efficiency at input (x) and output vectors (q):

$$SE(x, q) = D_I(x, q)_{VRS}/D_I(x, q)_{CRS} = TE_{CRS}/TE_{VRS} \tag{5}$$

In general, technical, allocative and scale efficiencies are greater than zero or less than or equal

to one. Mathematically, $0 < (TE \; or \; AE \; or \; SE) \leq 1$. Then, *(TE or AE or SE)* = 1 implies that the

firm is technically, allocatively, and scale efficient. Alternatively, $(TE \text{ or } AE \text{ or } SE) < 1$ indicates the presence of inefficiency.

3.4.3 Economies of Scope

Economy of scale allows firms to increase their production and decrease average unit cost (Shepherd, 1979). Fixed input costs are spread over a larger quantity of output as firms produce more output, resulting in a lower unit average cost. The concept of scale economies helps researchers to assess the efficiency of firm size. However, it does not address the issue of why some firms decide to produce more than one product. The reason for multiple outputs may be inherent economies of scope. Economies of scope are present if a reduction in average cost is realized by producing two or more outputs. Scope efficiency (Coelli, 2005) can be measured as:

$$SC(x,q) = \left\{ \sum_{j=1}^{k} c(w,q_j) - c(w,q) / c(w,q), \qquad q = \sum_{j=1}^{k} q_j \right\} \tag{6}$$

where q_j is output of the jth specialized product. $\sum_{j=1}^{k} c(w,q_j)$ is the sum of the costs of producing the jth output. $c(w,q)$ is the cost of producing multiple outputs. Economies of scope exist if $\sum_{j=1}^{k} c(w,q_j) > c(w,q)$. If $\sum_{j=1}^{k} c(w,q_j) < c(w,q)$, then there are diseconomies of scope. Thus, $SC > 1$ (<1) implies economies (diseconomies) of scope. More specifically, firms can be more cost efficient by diversification in production if economies of scope exist.

3.5 Estimation of an IDF Using Stochastic Frontier Analysis (SFA)

The efficiency components can be measured without difficulty after estimating the production technology parameters. The question is how to estimate the production technology. What estimation methods need to be used for the estimation of the production technology? There are many statistical, econometric and mathematical methods used to estimate production efficiency measurements. The most popular methods, as mentioned above, are SPF and DEA.

The SPF function (Aigner et al., 1977; Meeusen and J. van den Broeck, 1977) was developed to explain uncontrollable measurement errors and other noise within the data.

For the study proposed here, the SPF method is preferred because data noise is an important issue when production performance and efficiency analysis are of interest. DEA involves using the linear programming method by constructing a non-parametric piece-wise linear frontier over the top of the sample data. The piece-wise linear frontier will shift out and overstate or understate the mean value of technical efficiency if there is data noise associated with a few frontier points. These outliers will destroy the "correct" position of the estimated frontier. Therefore, the consequence is that the wrong estimation of the production efficiency measurements would be obtained (Coelli et al. 2003).

The study uses the IDF procedure approximated by using a translog functional form for empirical implementation in order to limit a priori restrictions on the relationship among inputs. The translog IDF is a flexible form and has fewer restrictions than the Cobb-Douglas production functional form on production and substitution elasticities. It is also embedded in a system of equations and has a number of potential advantages.

Coelli et al. (2007) found a number of potential advantages of the translog input distance function: (1) one can obtain more efficient econometric estimates of the parameters, (2) one can formally test the hypothesis of systematic deviations from the production technology frontier, (3) the issue of potentially endogenous regressors in the distance function could be addressed using the first order equations, (4) scope economies can be determined from the translog input distance function (there is no need to estimate a cost function), and (5) firm-specific technical inefficiency measures as a by-product of estimation can be obtained. This could allow one to avoid estimation

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of technical inefficiency drivers in a second stage, which generally involves the solution of a non-linear optimizing problem for each data point when a flexible functional form is used.

Coelli et al. (2003) argued some disadvantages of the cost function. According to Coelli et al. (2003), in some cases, the direct estimation of a cost frontier may not be practical or appropriate when input prices do not differ among firms and there is systematic deviation from cost-minimizing behavior in an industry. An example is when political, union or regulatory factors cause shadow prices to deviate from market prices in a systematic way. In this situation, the duality between cost and production functions breaks down, and the cost efficiency calculation and decomposition will be biased by the resulting biased estimates of the cost frontier (Coelli, 2003).

The IDF is specified as $D^I(X, Q, R)$ for this study, where X denotes a vector of inputs, Q denotes a vector of outputs, and R refers to a vector of farm efficiency determinants. For the meat goat whole farm IDF analysis, two outputs are developed from the data collected in our survey: Q_{GOATV} = value of meat goat production including meat goat breeding stock; $Q_{VCROPLIVE}$= value of all other crop and livestock production.

Inputs are: X_{LND}= quality-adjusted land price (we discuss this more extensively in the following paragraph); X_{FEED}= feed expenses; X_{TFIXED}= total fixed expenses including depreciation, insurance expenses, interest expenses, property taxes, and rental and lease payment expenses; and X_{TVAR}= total variable expenses including marketing charges, seed and plant expenses, fertilizer and chemical expenses, purchased livestock expenses, bedding and litter expenses, medical supplies including veterinary and custom services, fuel and oil expenses, electricity expense, all other utility expenses, farm supplies and marketing containers including hand tools, maintenance and repair including parts and accessories expenses, total labor

expenses, machine hire and custom work expenses, other livestock related expenses, and other variable expenses.

Land is a major and essential input for livestock production. Land productivity depends on many factors such as soil type, soil characteristics, urban influence, location (region, state) and other productivity-related factors. Therefore, land values of farms are different in urban and rural areas and they cannot be directly compared. Nehring et al. (2006) pointed out that, "The land market's capitalization of spatial differences in land quality and urban influence means that the observed value of land on farms in urban areas represents not only the value of land in agriculture use, but its use in alternative urban uses, thus preventing the direct comparison of observed land prices from rural and urban areas for use in efficiency analysis". Therefore, not accounting for land capitalization and spatial differences leads to a biased measure of the land input resulting in biased technical efficiency scores (Alvarez and Gonzales, 1999). Hence, we used the quality-adjusted price of land for the U.S. estimated in Ball et al. (2008). To account for the effect of differences in land characteristics on land prices, hedonic regression techniques were used to construct a quality-adjusted land input (Ball et al. 1997, 2001, 2008; Nehring et al. 2006). Nehring et al. (2006) computed quality-adjusted land prices by farm using physical characteristics of observations by Agricultural Statistics Districts (ASDs) and used hedonic techniques. They used a semilog model to estimate the price of land in 1998 on 88 ASD dummies (3,363 observations), level of urban influence, 10 climatic characteristics, 9 physical characteristics, and the percentage of cropland irrigated (see Nehring et al., 2006, for more detail). The estimated 2004 quality-adjusted land price by the U.S. states allows us to construct a state-level quality-adjusted land input value for use in econometric estimation of the IDF. The state-level quality-adjusted land values for 2011 were calculated by multiplying the

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proportionate differences between the 2004 and 2011 land values of the U.S. states by the

estimated 2004 state-level quality-adjusted land price. The estimated state level quality-adjusted

land value for each observation is multiplied by the actual acres of total goat farm land and a

service flow is computed based on a service life of 10 years and an interest rate of 6 percent

(Nehring et al., 2006). The quality-adjusted land price for goat farms is divided by the service

flow to express land input for our study as the service flow of the quality-adjusted land value.

The whole farm IDF can be approximated using a translog functional form for empirical

implementation in order to limit a priori restrictions on the relationship among inputs. A translog

functional form for the production technology is specified as:

$$lnD_i^I(X,Q,R) = \alpha_0 + \sum_m \alpha_m \ln X_{mi} + \frac{1}{2}\sum_m \sum_n \alpha_{mn} lnX_{mi}lnX_{ni} + \sum_k \beta_k \, lnQ_{ki} +$$

$$\frac{1}{2}\sum_k \sum_l \beta_{kl} \, lnQ_{ki}lnQ_{li} + \sum_q \delta_q \, R_{qi} + \frac{1}{2}\sum_q \sum_r \gamma_{qr} \, lnR_{qi}lnR_{ri} + \sum_k \sum_m \theta_{km} \, lnQ_{kit}lnX_{mi} +$$

$$+ \sum_q \sum_m \varphi_{qm} \, lnR_{qit}lnX_{mi} + \sum_k \sum_q \tau_{kq} \, lnQ_{ki}lnR_{qi} + v_i = TL(X,Q,R) + v_i \qquad (7)$$

Homogeneity of degree 1 in inputs implies the parametric restrictions:

$$\sum_m \alpha_m = 1 \qquad \sum_n \alpha_{mn} = 0 \qquad \sum_k \theta_{km} = 0 \quad \sum_q \varphi_{qm} = 0 \qquad (8)$$

By Young's theorem, the symmetry restrictions are:

$$\alpha_{mn} = \alpha_{nm}, \quad \beta_{kl} = \beta_{lk} \text{ and } \gamma_{qr} = \gamma_{rq} \quad \forall m,n,k,l,q,r \qquad (9)$$

Dividing all inputs and the distance term $(D_i^I(X,Q,R))$ by an input, the service flow of the

quality-adjusted land, specified as $X_1 = X_{LAND}$ which is consistent with much of the literature on

land-based farm production, is the same as imposing the homogeneity restrictions. The function

is specified on per dollar of quality adjusted land basis as:

$$ln\frac{D_i^I(X,Q,R)}{X_{1,i}} = \alpha_0 + \sum_m \alpha_m \ln X_{mi}^* + \frac{1}{2}\sum_m \sum_n \alpha_{mn} lnX_{mi}^*lnX_{ni}^* + \sum_k \beta_k \, lnQ_{ki}$$

$$+\frac{1}{2}\sum_k \sum_l \beta_{kl} \, lnQ_{ki}lnQ_{li} + \sum_q \delta_q \, R_{qi} + \frac{1}{2}\sum_q \sum_r \gamma_{qr} \, lnR_{qi}lnR_{ri} + \sum_k \sum_m \theta_{km} \, lnQ_{ki}lnX_{mi}^*$$

$$+ \sum_q \sum_m \varphi_{qm} \, lnR_{qit}lnX_{mi}^* + \sum_k \sum_q \tau_{kq} \, lnQ_{ki}lnR_{qi} + v_i = TL(X^*,Q,R) + v_i \qquad (10)$$

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Equation (10) can be written as

$$- \ln X_{1,i} = TL(X^*, Q, R) + v_i - \ln D_i^I(X, Q, R) = TL(X^*, Q, R) + v_i - u_i \qquad (11)$$

where i denotes farms; k, l the outputs; m, n the inputs; and q, r the farm characteristic variables. X_1 is land, specified as a normalization factor in inputs. An asterisk symbol in the input variables (X^*) indicates a ratio of all input variable values to the quality adjusted land price. $\ln D_i^I(X, Q, R)$ is the distance from the frontier and it characterizes the technical inefficiency (TI) error, $-u_i$. TI is a function of farm- and farmer-specific characteristics. Technical efficiency (TE) can be obtained as the expectation of the term $-u_i$ conditional on the composed error term $\varepsilon_i = v_i - u_i$ (Jondrow et al., 1982). TE can be measured as $TE = exp^{-u_i}$

The study uses single-step maximum likelihood methods (Battese and Coelli, 1995) to estimate (13) as an error components model. More precisely, the parameters of the IDF and the TI are estimated jointly using SPF techniques. The random error component v_{it} is independently and identically distributed, $N(0, \sigma_v^2)$. The one-sided error component of $u_i \geq 0$ is a random variable independently distributed with truncation at zero of the $N(m_i, \sigma_u^2)$ distribution, where $m_i = \sum_n F_n \tau$, F_n is a vector of whole-farm efficiency determinants, and τ are unknown estimable parameters.

Farmer demographics and farm-specific characteristics (R) are also included from the first meat goat survey data that impact technical efficiency of meat goat farm. Farm structure characteristics include: production systems; percentage of goat sales for slaughter or as meat, for use as breeding stock, and show; percentage of annual net farm income from goat operations; regions; whether meat goat production was organic, transitional or non-organic; and size of the operation.

Production systems consist of extensive-range or pasture/woods (not handled much), pastured but not rotated, pastured and rotated, and dry lot production systems. The questionnaire asked producers to report the number of breeding-aged goats in each of the four systems. We combined the percentage of breeding-aged goats in extensive-range or pasture/woods and pastured but not rotated systems and defined this variable as *Extensive-range and Pasture not Rotated*. An extensive-range or pasture/woods production system allows goats to browse freely on large pasture or rangeland and uses little labor, fertilizer, and capital inputs. The pastured but not rotated production system also requires less producer participation in farm production on a daily basis, and few capital and other inputs are required compared to an intensive production system. Producers in the pastured and rotated production system are generally more heavily involved with their goats on a daily basis. This system requires more inputs of labor and capital but less usage of land. As an intensive production system, producers have the potential to more extensively incorporate new technologies and management practices to improve meat goat efficiency. Harrison (1980) found that sheep farmers who used an intensive (rotational) production system gradually increased sheep numbers, lamb production, and net returns. Implementing rotational grazing systems, beef cattle producers have improved efficiency and productivity and increased returns (Eldridge et al., 2005). A dry lot system is an alternative production system to the above discussed systems in which producers completely depends on purchased feed, hay and other supplementary feed stuffs to raise and produce animals. A dry lot production system requires additional labor resources, facilities, faster depreciation of capital assets, and increased maintenance cost. In addition, feed costs tend to be higher and disease and health problems can be serious for raising animals. It is expected that *Extensive-range and*

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Pasture not Rotated, and *Pastured and Rotated* production systems have an impact on meat goat farm productivity and technical efficiency relative to *Dry lot* production system.

Another characteristic of farm production structure is goat sales for targeted markets. In the questionnaire, we asked producers to report the percentage of their goat sales that were for slaughter or as meat, for further use as breeding stock, and for show. The variables, *% Sales Breeding Stock / Show* and *% Sales Slaughter / Other*, refer to the percentages of goat sales for breeding stock / show and the percentages of goat sales for slaughter / other purposes, respectively, to those targeted markets. Raising goats for breeding stock or for show is likely to result in higher cost, but also higher revenue. The variable *Organic* is a dummy variable indicating whether the farm is producing certified organic meat goats. Organic livestock production has increased over the past two decades because of increased demand for organically grown meat. Many consumers prefer organic meat based on perceptions of environmental and food safety standards. The rules and regulations for organic meat production can be found in the Organic Foods Production Act (OFPA) of 1990. Certified organic meat is generally more expensive than conventional meat because it requires greater labor inputs, any land on which goats may be grazed or where feed for goats is harvested must be under certified organic production, etc.

Degree of specialization or percentage of income from beef cows increased technical inefficiency, indicating that significant economies of scope may be present in beef production (Featherstone et al., 1997). They also argued that beef cattle producers in Kansas who were diversified were more efficient than producers who were more specialized. We use *% Farm Income Goat* variable in this study, which indicates the percentage of farm income from the meat goat enterprise. The variable *Off-farm Job* is included in this study as a dummy variable

indicating whether the farmer held off-farm employment. On the one hand, farmers holding off-farm employment spend less time on the farm with their animals, potentially resulting in lower output. On the other hand, off-farm employment allows farmers to use off-farm income to invest in farm production. Nehring et al. (2009) found that U.S. corn and cow-calf producers, respectively, who held off-farm employment or had off-farm income boosted small scale operations' scale and technical efficiency.

The U.S. regions have different forage availability, grazing periods, and weather conditions, and require different housing for goat production. Therefore, the U.S. regions may have different impacts on meat goat production efficiency. We include three regional variables: *Southeast*, *Northeast*, and *West* in this study. The *Southeast* in our study is composed of Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. Oklahoma and Texas are divided on a line corresponding to north-south Interstate 35, with the eastern halves of these two states being included in the *Southeast* region. The southernmost counties of Missouri are included in the *Southeast* region. The *West* in our study is composed of Kansas, Nebraska, South Dakota, North Dakota, Western Oklahoma, Western Texas, New Mexico, Colorado, Wyoming, Montano, Arizona, Utah, Idaho, California, Nevada, Oregon, and Washington. The *Northeast* in our study is composed of Northern Missouri, Iowa, Minnesota, Illinois, Wisconsin, Indiana, Michigan, Ohio, Pennsylvania, Maryland, Delaware, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont, and Maine.

Large-sized farms have generally been more efficient than small-sized. Morrison-Paul et al. (2004a) found that small family corn producers in the U.S. were generally less efficient in terms of both their scale of operations and technical aspects of production than large farms. The

sizes of operations were divided into three groups: *Small Farms* (<20 meat goats on the operation), *Medium Farms* (≥20 and <100 meat goats on the operation), and *Large Farms* (≥100 meat goats on the operation) in this study. It is expected that larger farms are more technically efficient than smaller farms.

Farmer demographics included in this study were education level (*College*), *Age*, *Gender*, and *Experience*. Farmers with college degrees have generally been more technically efficient. Pruitt et al. (2012) found that farmers with college degree were more likely to adopt new technologies in the U.S. cow-calf production. Rakipova, Gillespie and Franke (2003) found that Louisiana beef cattle producers with college degree were more technically efficient. A college degree is expected to have a positive impact on technical efficiency. Studies have found mixed results for the impact of farmer age on production efficiency. Amara et al. (1999) found that Quebec potato farmers with more experience in farming were more technically efficient. It can be argued that producers may attempt to reduce their commitment to the farm production as they get older. Therefore, older farmers have generally been technically more inefficient than younger farmers. Featherstone et al. (1997) found that older beef cattle producers were less technically efficient than younger ones. Nehring et al. (2005b) also found that older U.S. corn producers were less technical efficient. It is expected that farmer age is negatively associated with technical efficiency, increasing farm inefficiency. The variable *Gender* is a dummy variable indicating that the meat goat operator is female, with the base as a male operator. The variable *Experience* is the number of years raising goats. It is included in the inefficiency model to capture the increased effect of experience on meat goat farm technical efficiency. Farmers with more farming experience are likely to have more knowledge about their farms and farming practices; therefore, *Experience* has generally had a positive impact on technical efficiency. Ogunniyi

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(2010) found that Nigerian goat farmers with more years of goat farm establishment were more technically and economically efficient.

This study also uses the IDF to examine meat goat enterprise production performance measures. As with the whole-farm analysis, to estimate the meat goat enterprise IDF econometrically, the study applies the SPF framework. For the meat goat enterprise IDF analysis, two outputs are developed from the data collected in our survey: $Q_{MGOATBS}$ = value of meat goat breeding stock production, and Q_{MGOAT} = value of all meat goats for slaughter and goat meat production. Meat goat breeding stock production may differ in input usage from commercial meat goat or goat meat production systems. Input variables are the same as in the meat goat whole farm analysis. However, they are the meat goat enterprise production expenditures and we did not request enterprise-specific expenses for some input variables in the questionnaire. In order to get enterprise-specific expenses for those input variables, first, the percentage or portion of the meat goat enterprise total return is calculated as the total meat goat enterprise return divided by the total whole farm return. Second, to identify the meat goat enterprise-specific expenses for these variables, the whole farm input variable expenses were multiplied by the coefficient of the ratio for those expenses where farmers were not specifically asked to allocate them to the meat goat enterprise. To be consistent with the meat goat whole farm analysis, the same farmer and farm-specific variables were used for the meat goat enterprise. Farm characteristics include: production systems, percentage of income from meat goat operations, regions, and size of operations. Operator characteristics include education level, gender and age. Again, (7), (8), (9), (10), and (11) steps are used to empirically implement the meat goat enterprise IDF, and it is estimated using SPF techniques.

The U.S. Southeast region is the major U.S. meat goat production region. Therefore, it is of interest to examine this region's meat goat productivity separately. The same IDF analysis that is used for the whole U.S. meat goat farms (except that sub-regions of the Southeast are used rather than the larger U.S. regions) is used for the U.S. Southeastern region meat goat analysis. The Southeast includes parts of the following farm resource regions as designated by USDA-ERS (Figure 6): Eastern Uplands, Fruitful Rim, Mississippi Portal, and Southern Seaboard. Southeastern states include Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. Parts of Oklahoma and Texas are included, divided on a line corresponding to north-south Interstate 35, with the eastern halves of these states being included in the Southeast region. The U.S. and the U.S. Southeastern region include 124 and 69 observations, respectively, for the IDF analysis.
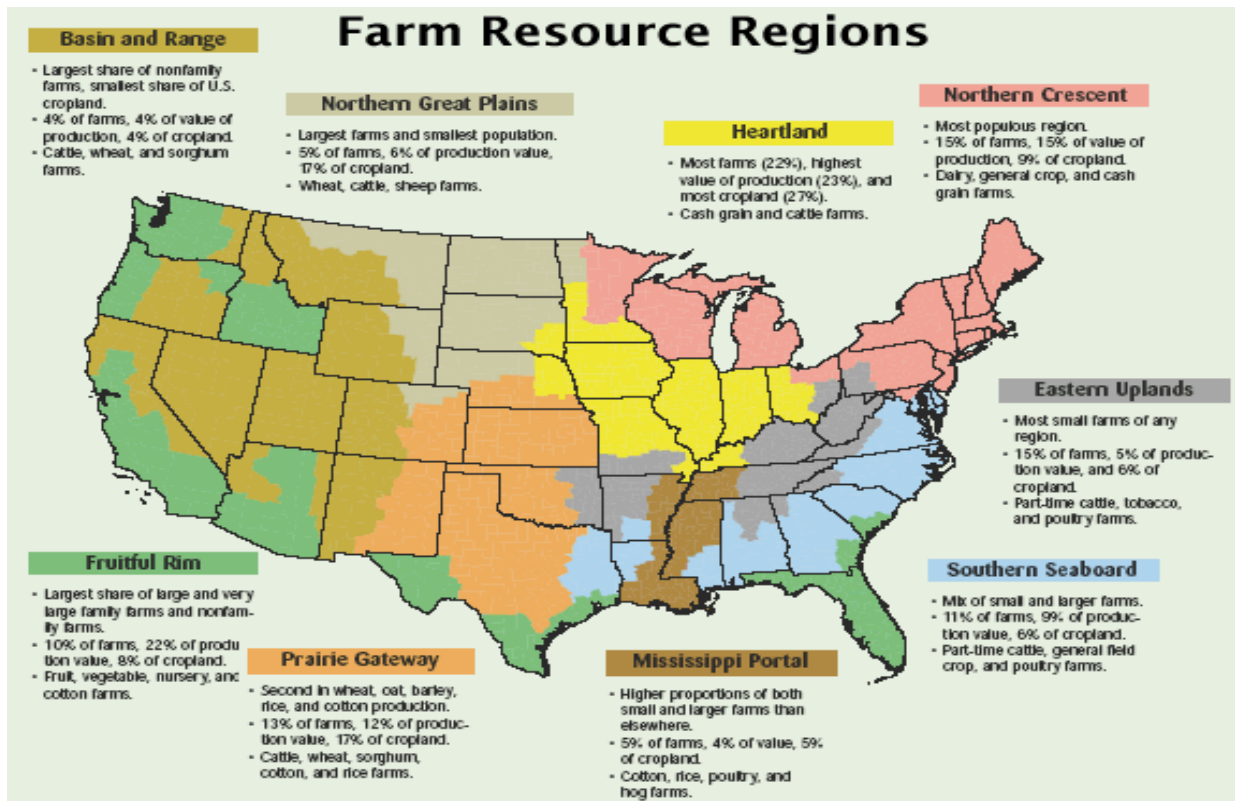
Figure 6. U.S. Farm Resource Regions; Source: USDA ERS

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3.5.1 One-Step Estimation Methods in SFA Models

Let us reconsider the stochastic frontier model of equation (1) above

$$y_i = f(X_i; \beta) + v_i - u_i, \qquad i = 1, \ldots, n \tag{12}$$

where y_i is output, X_i represents inputs, v_i is a normally distributed error term, and $u_i \geq 0$ is the non-negative technical inefficiency level. Suppose that there is a vector z_i of exogenous variables that influences the technical inefficiency, u_i. Assume that technical inefficiency is a function of these exogenous variables.

Stochastic frontier models are estimated using two-step or one-step estimation methods. One-step methods estimate the frontier model and technical inefficiency model using the single-step maximum likelihood method. In contrast, two-step methods have the following two steps. In the first step, the stochastic frontier model is estimated as if u_i did not depend on z_i, and $\hat{u}_i$ of u_i is obtained. In the second step, the relationship between $\hat{u}_i$ and z_i is estimated using one of several possible regression models such as truncated regression.

This study uses the one-step method to estimate input distance functions using maximum likelihood techniques. There are a few reasons that two-step methods are not recommended (Schmidt, 2011). Accordingly with least squares regression, if z_i exogenous variables are omitted in the first step of a two-step estimation in which z_i affects y_i and X_i and z_i are correlated, then β will be biased. The first step results using two-step methods are biased if X_i and z_i are correlated and Monte Carlo simulations show that the bias can be very severe (Wang and Schmidt, 2002).

This bias is not because of the frontier model being stochastic, and it is not because of the frontier model being linear or even parametric. It is the difference between $E(y|x,z)$ and $E(y|x)$, and the problem occurs even with a kernel-based estimate of $E(y|x)$ (Schmidt, 2011). A second and neglected problem in the first-step estimation is that technical efficiency measures are likely

to be seriously under-dispersed, resulting in the second-step regression estimates being biased downward (Wang and Schmidt, 2002). In other words, the effect of z_i on u_i is underestimated. Therefore, the second problem is true regardless of whether X_i and z_i are correlated (Wang and Schmidt, 2002). The bias problem in the second-step regression was studied extensively and shown using Monte Carlo simulation by Wang and Schmidt (2002). Schmidt (2011) also discussed a third problem with two-step estimation. He pointed out that testing whether coefficients of z_i are equal to zero or $\delta = 0$ is a non-standard test. If there is no effect of z_i on u_i, then there is no bias in the second step, and the hypothesis test $\delta = 0$ is true. Therefore, we can hope to employ a simpler testing procedure based on $\hat{\delta}_{2-step}$, or in a similar simple measure of the correlation between $\hat{u}_i$ and z_i (Schmidt, 2011). However, simple tests are not possible because the estimation error in $\hat{u}_i$ is relevant, even asymptotically, and it changes the asymptotic distribution of the test (Schmidt, 2011). Wang and Schmidt (2002), Kim and Schmidt (2008), and Schmidt (2011) provide a more detailed discussion of two-step estimation problems.

Therefore, this study uses a single-step, or one-step method, to estimate input distance functions using stochastic production frontier analysis. Additionally, MC simulation procedures show that the one-step estimators generally perform quite well in finite samples (Wang and Schmidt, 2002). Thus, this study also employs a MC simulation technique to investigate small-sample properties in stochastic production frontier models.

3.6 Monte Carlo (MC) Simulation in Stochastic Production Frontier (SPF) Models

Simulation methods have become a popular tool to study statistical concepts in all areas of research. The MC method has been used extensively by econometricians and applied economic researchers when studying finite-sample properties. The MC simulation is a useful and powerful methodology to investigate the properties of econometric estimators as well as

statistical tests (Cameron and Trivedi, 2009). MC simulation is defined by Kennedy (2003) as a simulation technique designed to clarify the finite-sample properties of competing estimators for a given estimation problem. It is important to use valid statistical inferences of finite-sample distributions. MC simulation methods provide these statistical inferences throughout the repeated sample and sampling distribution concepts.

To verify validity of statistical inferences in finite-sample estimates, studies often rely on asymptotic results. However, these asymptotic procedures have different properties in finite samples, and therefore, MC simulation experiments enable finite-sample comparisons (Cameron and Trivedi, 2009). The idea behind the MC simulation experiment is to model the data generation process (DGP). In the second step, artificial data sets are generated based on the DGP. The parameters of the model are estimated using one or more estimators. Summary statistics or plots are used to compare or study the performance of the estimators.

We employ a MC simulation model to investigate the sampling properties of U.S. meat goat farms and conduct hypothetical and empirical simulations. The difference between hypothetical and empirical simulations is that the empirical simulation technique creates a DGP based on the survey data. This study has 124 farms which represents the population of the U.S. meat goat farms that advertise via the internet. There were 100,910 total meat goat farms in the U.S. in 2012 (2012 Census of Agriculture). A thorough internet search yielded just 1,600 that advertised via the internet. The small sample size may result in the lack of statistical representation of the population. So, there is a concern of consistency of estimation of the small sample size. As we know, an estimator is consistent if, as the sample size increases, the estimator "converges" to the true value of the parameter being estimated. Therefore, this study conducts empirical Monte Carlo simulation models to show consistency that as the sample size increases,

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the sampling distribution of the estimator becomes increasingly concentrated at the true

parameter value. In general, empirical MC simulation models are designed to shed light on the

consistency of small-sample properties of the survey data.

CHAPTER 4: RESULTS

4.1 T-Test for a Difference in Means of Two Samples

As discussed in the previous chapter, the data for this study were from both a first survey questionnaire including farm and farmer characteristics and a second survey questionnaire for costs and returns. Therefore, one could consider our costs and returns data as a subsample of the first survey data. For that reason, there was concern as to whether there were differences between the first survey and the follow-up survey sample means. In order to compare the means of several variables in the first survey and the follow-up survey, we conducted t-tests to determine whether there were statistically significant differences in means between the surveys. The formula for the t-test is given by

$$t = (\bar{x}_s - \bar{x}_{ss}) \Big/ \sqrt{\frac{s_s^2}{n_s} + \frac{s_{ss}^2}{n_{ss}}} \qquad\qquad 4.1.1$$

where $\bar{x}_s$ is the mean for the sample, $\bar{x}_{ss}$ is the mean for the subsample, s_s^2 and s_{ss}^2 are standard deviations, and n_s and n_{ss} are the sample and the subsample sizes, respectively.

The number of degrees of freedom is computed using the following formula:

$$d.o.f = \left(\frac{s_s^2}{n_s} + \frac{s_{ss}^2}{n_{ss}}\right)^2 \Big/ \left(\frac{s_s^4}{n_s^2(n_s - 1)} + \frac{s_{ss}^4}{n_{ss}^2(n_{ss} - 1)}\right) \qquad\qquad 4.1.2$$

The hypothesis H is defined as:

- Null Hypothesis $H_0: \bar{x}_s = \bar{x}_{ss}$

- Alternative Hypothesis $H_A: \bar{x}_s \neq \bar{x}_{ss}$

The results of the t-tests suggest failure to reject the null hypothesis, concluding that there is not sufficient evidence to suggest the first survey and the follow-up survey population means are different at $p \leq 0.10$ levels. Table 4 shows the t-test values and p-value for selected variable means for both the first and the second survey samples.

Table 4. T-test Results for Sample and Subsample Survey Variable Means

Variables	T-test Value	P - Value
Herd size	1.31	0.19
Number of breeding goats	1.24	0.21
Farm income from goat operations	-1.06	0.29
Sales for breeding stock and show	-0.30	0.76
Sales for slaughter and other	0.30	0.76
Total farm land	1.52	0.12
Years farming	1.45	0.15

4.2 Descriptive Statistics

Descriptive statistics of variables and U.S. meat goat whole farm and/or farmer characteristics are presented in Table 5. U.S. meat goat enterprise expenses are also included in parentheses in Table 5. The average quality-adjusted total land values of meat goat farm adjusted to the service flow were $15,888.17 and $4,847.77 per farm, respectively, for the meat goat whole farm and the meat goat enterprise. The average feed expenses for the meat goat operations were $5,381.84 and $3,986.84 per operation, respectively, for the meat goat whole farm and the meat goat enterprise. Total other variable expenses were $13,498.57 and $7,397.76 per operation, respectively, for the meat goat whole farm and the meat goat enterprise, on average. Total fixed expenses were $7,856.96 and $3,769.96 per operation, respectively, for the meat goat whole farm and the meat goat enterprise, on average. The feed expense was the highest expenditure among all input expenses not including land.

Sixty-six percent of the meat goat farms in this sample had 20 to 100 meat goats on their operations. Twenty-two percent of the meat goat farms had less than 20 meat goats. Twelve percent of the meat goat farms had 100 or more meat goats. Respondents had at least some college or a technical college degree, on average. The average meat goat farm received 20 to 39 percent of its total annual net farm income from the goat enterprise. Fifty-two percent of the

meat goat farmers resided in the Southeast. Thirty percent of the meat goat farmers resided in the

Northeast, while only 18 percent resided in the West. Respondents reported that the average

Table 5. Summary Statistics and Variable Definitions for US Meat Goat Producers

Variable	Definition	Mean	Std. Dev.
Land	Quality-adjusted total land value, service flow in dollar value	15,888.17	55,846.77
		(4,847.77)[1]	(9,763.28)
Feed	Total farm feed expenses in dollar value	5,381.84	7,416.23
		(3,986.51)	(6,202.27)
Variable	Total other variable expenses in dollar value	13,498.57	16,578.54
		(7,397.76)	(10,005.18)
Fixed	Total fixed expenses in dollar value	7,856.96	10,535.51
		(3,769.35)	(5,871.67)
Small farm	Total number of meat goats < 20	0.22	0.41
Medium farm	Total number of meat goats >= 20 and <100	0.66	0.47
Large farm	Total number of meat goats >= 100	0.12	0.32
Education	1 = less than high school; 2 = high school; 3 = some college;		
	4 = Bachelor's; 5 = Advanced degrees	3.56	1.01
Goat income	% of annual net farm income from goat operations: 1 = <=		
	19; 2 = 20 - 39; 3 = 40 - 59; 4 = 60 - 79; 5 = 80 - 100	2.70	1.77
Southeast	1 = if region is southeast; 0 = otherwise	0.52	0.50
Northeast	1 = if region is northeast; 0 = otherwise	0.30	0.46
West	1 = if region is west; 0 = otherwise	0.18	0.38
Extensive range and pasture	Total number of breeding-aged goats on farm in the extensive-range production system	6.76	25.52
Pasture without rotation	Total number of breeding-aged goats on farm in the pastured but not rotated production system	15.01	28.69
Pasture with rotation	Total number of breeding-aged goats on farm in the pastured and rotated production system	18.95	34.93
Dry lot	Total number of breeding-aged goats on farm in the dry lot production system	5.11	15.67
Off-farm job	1 = if farm operator has off-farm job; 0 = otherwise	0.65	0.48
Goat operations	1 = certified organic; 2 = traditional; 3 = transitional	2.02	0.20
Gender	1 = male; 0 = female	0.59	0.49
Farm experience	Total number of years raising goats: 1 = <=10 ; 2 = 11 to 20;		
	3 = 21 to 30; 4 = 31 to 40; 5 = >= 41	1.50	0.75
Breeding stock	% of goat sales for breeding stock	32.60	30.70
Show	% of goat sales for show	16.86	27.42
Slaughter	% of goat sales for slaughter	41.94	35.85
Sales for other	% of goat sales for other	4.17	14.63

[1]Numbers in parentheses are mean and their standard deviations for goat enterprise expenses.

farm included almost 19 breeding-aged animals in pasture with rotation systems and about 15

breeding-aged animals in pasture without rotational production systems. On average, the lowest

numbers of breeding-aged goats were in dry-lot production systems (just over 5 per operation). On average, there were 7 breeding-aged goats on the farm in the extensive-range or pasture/woods (not handled much) production system.

Of the 124 respondents in the sample population, 65 percent indicated that they held off-farm jobs. Most respondents reported that their meat goat operations were neither organic nor transitioning. Just over four percent of the meat goat farmers were organic and /or transitioning. Of the 124 meat goat operators, 59 percent were male and 41 percent were female. On average, meat goat farmers in the sample had been raising goats a little less than 10 years. Most of the meat goat farmers sold their goats for slaughter or as meat (42%) or as breeding stock (33%). On average, respondents sold 17% and 4% of their goats for show and other purposes, respectively.

Descriptive statistics of variables for Southeastern U.S. meat goat farm/farmer characteristics are presented in Table 6. Southeastern U.S. meat goat enterprise expenses are included in parentheses in Table 6. The average quality-adjusted total land values of meat goat farms adjusted to the service flow were $8,316.70 and $4,444.70, respectively, for the whole farm and the meat goat enterprise. The average feed expenses were $4,109.26 and $3,333.53 per farm, respectively, for the meat goat whole farm and the meat goat enterprise. On average, total other variable expenses were $10,555.13 and $6,067.26 per operation, respectively, for the meat goat whole farm and the meat goat enterprise. On average, total fixed expenses were $6,213.59 and $2,412.88 per operation, respectively, for the meat goat whole farm and meat goat enterprise. However, the feed expense was the highest expenditure among all input expenses except for land. Fifty-nine percent of the meat goat farms had 20 to 100 meat goats on their operations. Twenty-nine percent of the meat goat farms had less than 20 meat goats on their operations. Twelve percent of the meat goat farms had 100 or more goats on their operations. On

average, respondents had at least some college or a technical college degree. Meat goat farmers received an average of 20 to 39 percent of their total annual net farm income from the meat goat enterprise.

Table 6. Summary Statistics for Southeastern US Meat Goat Producers

Variable	Definition	Mean	Std. Dev.
Land	Quality-adjusted total land price, service flow in dollar value	8,316.70	12,453.13
		(4,444.70)[1]	(9,204.08)[1]
Feed	Total feed expenses in dollar value	4,109.26	6,644.32
		(3,333.53)[1]	(5,940.89)[1]
Variable	Total variable expenses in dollar value	10,555.13	15,168.37
		(6,067.26)[1]	(8,760.10)[1]
Fixed	Total fixed expenses in dollar value	6,213.59	10,736.31
		(2,412.88)[1]	(3,588.04)[1]
Small farm	Total number of meat goats < 20	0.29	0.46
Medium farm	Total number of meat goats >= 20 and <100	0.59	0.49
Large farm	Total number of meat goats >= 100	0.12	0.32
Education	1 = less than high school; 2 = high school; 3 = some college; 4 = Bachelor's; 5 = Advanced degree	3.45	0.87
Goat income	% of annual net farm income from goat operations: 1 = <= 19; 2 = 20 - 39; 3 = 40 - 59; 4 = 60 - 79; 5 = 80 - 100	2.87	1.77
EU	1 = Eastern Upland region; 0 = otherwise	0.29	0.46
FR	1 = Fruitful Rim region; 0 = otherwise	0.10	0.30
MP	1 = Mississippi Portal region; 0 = otherwise	0.07	0.26
SS	1 = Southern Seaboard region; 0 = otherwise	0.54	0.50
Extensive range and pasture	Total number of breeding-aged goats on farm in the extensive-range production system	5.33	18.70
Pasture without rotation	Total number of breeding-aged goats on farm in the pastured but not rotated production system	11.64	22.97
Pasture with rotation	Total number of breeding-aged goats on farm in the pastured and rotated production system	19.58	37.13
Dry lot	Total number of breeding-aged goats on farm in the dry lot production system	2.23	6.21
Off-farm job	1 = if farm operator holds off-farm job; 0 = otherwise	0.62	0.49
Gender	1 = male; 0 = female	0.58	0.50
Age	1 = <= 30; 2 = 31 - 45; 3 = 46 - 60; 4 = 61 - 75; 5 = >= 76;	2.90	0.93
Farm experience	Total number of years raising goats: 1 = <= 10 ; 2 = 11 - 20; 3 = 21 - 30; 4 = 31 - 40; 5 = >= 41;	1.43	0.61
Sell goat meat	Marketing channel: 1 = sell goat meat; 0 = otherwise	0.09	0.28
Breeding stock	% of goat sales for breeding stock	33.14	32.67
Show	% of goat sales for show	17.19	29.93
Slaughter	% of goat sales for slaughter	38.84	35.99
Sales for other	% of goat sales for other	5.74	18.23

[1]Numbers in parentheses are mean and their standard deviations for goat enterprise expenses

Farm resource region characteristics indicated that more than half of the southeastern meat goat farmers in the sample (54%) resided in the Southern Seaboard region. Twenty-nine percent resided in the Eastern Upland farm resource region, and only 10 and 7 percent of the farmers resided in the Fruitful Rim and Mississippi Portal farm resource regions, respectively. Two production systems had a larger number of breeding-aged goats compared with the other two. On average, respondents indicated that they had more than 19 and more than 11 breeding-aged goats in pasture with rotation and pasture without rotation production systems, respectively. On average, 5 breeding-aged goats were in extensive-range and/or pasture/woods (not handled much) production systems. Finally, on average, there were more than 2 breeding-aged goats in dry-lot production systems.

Out of the total of 69 respondents in the sample, 62 percent of the meat goat farmers indicated that they held an off-farm job. Out of the total of 69 meat goat operators in the Southeast region, 58 percent were male and 42 percent were female. The Southeastern U.S. meat goat farmers in the sample reported that, on average, their age was between 31 and 45. On average, meat goat farmers reported that they had less than 10 years of experience raising goats. A few, 9 percent of the meat goat farmers in the Southeast, used the "sell goat meat" marketing channel. On average, most of the meat goat farmers in the Southeast sold their goats for slaughter or as meat (39%) and breeding stock (33%). Southeastern respondents reported that, on average, they sold 17% and 6% of their meat goats for show and other purposes, respectively.

4.3 IDF Analysis for U.S. Meat Goat Farms

The following input distance function was estimated for U.S. meat goat farms using stochastic frontier analysis:

$$- \ln X_{1,i} = \alpha_1 + \varphi_1 Y^d_{1,i} + \varphi_2 Y^d_{2,i} + \varphi_3 X^d_{2,i} + \varphi_4 X^d_{4,i} + \alpha_2 \ln X^*_{2,i} + \alpha_3 \ln X^*_{3,i} + \alpha_4 \ln X^*_{4,i} +$$

$$.5\alpha_5 \ln X^*_{2sq,i} + .5\alpha_6 \ln X^*_{3sq,i} + .5\alpha_7 \ln X^*_{4sq,i} + .5\alpha_8 \ln X^*_{2,i} \ln X^*_{3,i} + .5\alpha_9 \ln X^*_{2,i} \ln X^*_{4,i} +$$

$$.5\alpha_{10} \ln X^*_{3,i} \ln X^*_{4,i} + \beta_1 \ln Y_{1,i} + \beta_2 \ln Y_{2,i} + .5\beta_3 \ln Y_{1sq,i} + .5\beta_4 \ln Y_{2sq,i} + .5\beta_5 \ln Y_{1,i} \ln Y_{2,i} +$$

$$\theta_1 \ln Y_{1,i} \ln X^*_{2,i} + \theta_2 \ln Y_{2,i} \ln X^*_{2,i} + \theta_3 \ln Y_{1,i} \ln X^*_{3,i} + \theta_4 \ln Y_{2,i} \ln X^*_{3,i} + \theta_5 \ln Y_{1,i} \ln X^*_{4,i} + \theta_6 \ln Y_{2,i} \ln X^*_{4,i} +$$

$$\delta_1 R_{mf,i} + \delta_2 R_{lf,i} + v_i - u_i \qquad\qquad\qquad 4.3.1$$

where i = 1, …, 124 is the number of observations, and the dependent log variable $\ln X_{1,i}$ is the

service flow of the quality-adjusted land value for the ith farm. The input log variables $\ln X^*_{2,i}$,

$X^*_{3,i}$, and $\ln X^*_{4,i}$ are the values of feed expenses, total other variable expenses, and total fixed

expenses, respectively, each divided by the numeraire, quality-adjusted land value. For the U.S.

meat goat whole-farm analysis, we developed two outputs from the costs and returns data: output

log variables $\ln Y_{1,i}$[1] and $\ln Y_{2,i}$[2] are values of sales from all meat goats and all other livestock and

crops, respectively. For the U.S. meat goat enterprise analysis, we also developed two outputs

from the costs and returns data: $\ln Y_{1,i}$ is value of sales from meat goats for slaughter and/or goat

meat and $\ln Y_{2,i}$ is value of sales from meat goats for breeding stock. $R_{sf,i}$, $R_{mf,i}$ and $R_{lf,i}$ are the

dummy variables for small, medium, and large meat goat farm operations. $R_{mf,i}$ and $R_{lf,i}$ are

operation sizes with 20 to 100 and >100 meat goats, respectively. The base dummy variable is

$R_{sf,i}$ which has less than 20 meat goats in the operations. There are interactions between inputs

and outputs in the IDF analysis.

Output variables of Y_1, Y_2 and input variables of X_2, X_4 may have zero values. The zero

value observation is problematic in estimation of the translog function, resulting in biased

estimators of parameters of the chosen function (Battese, 1997). The coefficients of the variables

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[1] We defined output variable as $\ln Y_{1,i}$ in both U.S. meat goat whole-farm and enterprise models.

[2] We defined output variable as $\ln Y_{2,i}$ in both U.S. meat goat whole-farm and enterprise models.

associated with the zero observations can be estimated in an unbiased way by using dummy

variables (Battese, 1997). We used the following procedure to deal with zero observations:

$$\left.\begin{array}{l}Y_{1,i}^d = 1 \ if \ Y_{1,i} = 0 \ and \ Y_{1,i}^d = 0 \ if \ Y_{1,i} > 0, and \ Y_{1,i}^* = \max(Y_{1,i}, Y_{1,i}^d) \\ Y_{2,i}^d = 1 \ if \ Y_{2,i} = 0 \ and \ Y_{2,i}^d = 0 \ if \ Y_{2,i} > 0, and \ Y_{2,i}^* = \max(Y_{2,i}, Y_{2,i}^d) \\ X_{2,i}^d = 1 \ if \ X_{2,i} = 0 \ and \ X_{2,i}^d = 0 \ if \ X_{2,i} > 0, and \ X_{2,i}^* = \max(X_{2,i}, X_{2,i}^d) \\ X_{4,i}^d = 1 \ if \ X_{4,i} = 0 \ and \ X_{4,i}^d = 0 \ if \ X_{4,i} > 0, and \ X_{4,i}^* = \max(X_{4,i}, X_{4,i}^d) \end{array}\right\} \qquad 4.3.2$$

where $Y_{1,i}^d$, $Y_{2,i}^d$, $X_{2,i}^d$, and $X_{4,i}^d$ are dummy variables accounting for the intercept change.

The following meat goat farm technical inefficiency effects model was estimated as a

function of farm-farmer characteristics and regional dummies, as:

$$\sigma_u^2 = \exp\big(\tau_0 + \tau_1 F_{educ} + \tau_2 F_{goatincome} + \tau_3 F_{seast} + \tau_4 F_{neast} + \tau_5 F_{extrangpast} + \tau_6 F_{drylot} +$$

$$\tau_7 F_{breedstshowsales} + \tau_8 F_{offfarmjob} + \tau_9 F_{organic} + \tau_{10} F_{genderf} + \tau_{11} F_{farmexperience}\big) \qquad 4.3.3$$

where σ_u^2 is the variance of the one-sided error term of u_i, F_{educ} is the farm operator education

level dummy (1= bachelor or higher degree, 0 = otherwise), $F_{goatincome}$ is the percentage of

annual net farm income from the meat goat enterprise (1: <19%; 2: 20-39%; 3: 40-59%; 4: 60-79%;

5: 80-100%), F_{seast} and F_{neast} are regional dummy variables for the Southeastern and

Northeastern U.S. meat goat production regions, respectively (F_{west} is the Western goat

production region, considered as the base level), $F_{extrangpast}$ and F_{drylot} are goat production

system dummy variables for the extensive-range and pastured but not rotated and the dry lot

production systems, respectively ($F_{pastrot}$ is the pastured and rotated production system used as

the base level). $F_{breedstshowsales}$ is the percentage of goat sales for breeding stock and show.

$F_{offfarmjob}$ is a dummy variable for the operator holding an off-farm job. $F_{organic}$ indicates the

farm raised goats under a certified organic production system and transitioning to certified

organic production. $F_{genderf}$ is a dummy variable for a female meat goat operator (the base

category is a male operator). $F_{farmexperience}$ is a continuous variable indicating the number of

years the farmer has raised goats (1: ≤ 10 years; 2: 11-20 years; 3: 21-30 years; 4: 31-40 years; 5: ≥ 41 years).

We conducted a number of tests on the structural form of the translog model by incorporating restrictions on the parameters. The likelihood ratio test was used to test the restrictions on the parameters, where the test statistic is given by $LR = (-2 \ln \left[\frac{L(H_0)}{L(H_A)}\right])$, where $\ln[L(H_0)]$ and $\ln[L(H_A)]$ are the values of the likelihood function under the null and alternative hypothesis, respectively. The likelihood ratio test has a χ^2 distribution with the degrees of freedom given by the number of restrictions imposed in the translog model. The results of the test statistics with 5% level of significance are given in Table 7 and Table 8 for U.S. meat goat whole farms and enterprises models, respectively.

Table 7. The Likelihood Ratio Test Results for U.S. Meat Goat Whole Farm Model

H_0 Restrictions	Ln[L(H$_0$)]	Ln[L(H$_A$)]	LR	Critical χ^2	Number of Restrictions
No inefficiency $(\tau_0 = \tau_1 = \tau_2 = \cdots = \tau_{10} = \tau_{11})$	-105.95	-92.01	27.89	19.68	11
Cobb-Douglas production function $(\alpha_5 = \alpha_6 = \cdots = \alpha_{10} = \beta_3 = \cdots = \beta_5 = \theta_1 = \theta_2 = \cdots = \theta_6)$	-107.38	-92.01	30.75	25.00	15

Table 8. The Likelihood Ratio Test Results for U.S. Meat Goat Enterprise Model

H_0 Restrictions	Ln[L(H$_0$)]	Ln[L(H$_A$)]	LR	Critical χ^2	Number of Restrictions
No inefficiency $(\tau_0 = \tau_1 = \tau_2 = \cdots = \tau_{10} = \tau_{11})$	-95.77	-86.01	19.52	18.31	10
Cobb-Douglas production function $(\alpha_5 = \alpha_6 = \cdots = \alpha_{10} = \beta_3 = \cdots = \beta_5 = \theta_1 = \theta_2 = \cdots = \theta_6)$	-98.18	-86.01	26.30	25.00	15

First, we tested whether the explanatory variables in the whole farm and enterprise models for inefficiency effects contribute significantly to the explanation of technical inefficiency effects. The test results show that the explanatory variables in both inefficiency models contribute

significantly to the explanation of technical inefficiency effects. We also tested whether the

translog functional form describes better the underlining production technology of U.S. meat

goat farms relative to the alternative structural form of the Cobb-Douglas production function.

The results show that the translog model is the most appropriate functional form for both the

whole farm and enterprise models (Table 7 and 8).

We used a one-step maximum likelihood method to estimate equations (4.3.1) and (4.3.3)

simultaneously. The ML parameter estimates of the translog IDF for U.S. meat goat farms,

whole farm and enterprise, respectively, are presented in Table 9. The results of estimated

parameters of the Hessian matrix of the second-order partial derivatives with respect to inputs

and outputs were found to be negative and positive definite, respectively. These results indicated

that the underlying IDF for the U.S. meat goat production technology is concave and convex

with respect to inputs and outputs, respectively. Individual first-order elasticities characterize

input-specific or output-specific contributions and identify the productive contributions of farm

or farmer characteristics to production economies (Morrison-Paul and Nehring, 2005).

All input variable parameters for the U.S. meat goat whole farm model were statistically

significant. These input contributions were somewhat different. The contribution of feed (lnX_2^*)

was the largest input in magnitude, with the increase in feed expense decreasing the productive

contribution of land ($ln\ X_{1,i}$). The fixed expenses (lnX_4^*) had the smallest production contribution

in magnitude. The productive contribution of total other variable expenses (lnX_3^*) was almost

three times in magnitude that of the total fixed expense, but increasing total other variable

expenses increased the productive contribution of the land. Second-order elasticities reflect

production complementarities (or biases) that reflect economic performance impacts from output

or input jointness (Morrison-Paul and Nehring, 2005). The cross-input variable parameters were

statistically non-significant except for the total other variable and total fixed expenses

($lnX_3^* lnX_4^*$). The total other variable and total fixed expenses interaction was statistically

significant and positive, implying complementarity. This interaction suggests that increased total

Table 9. The IDF Estimates for U.S. Meat Goat Farms

Whole farm			Enterprise		
Variables	Coeff.	t-test	Variables	Coeff.	t-test
constant	10.06^{***}	3.64	constant	7.97^{***}	5.25
Y_1^d	-0.53	-0.28	Y_1^d	2.13	1.49
Y_2^d	-3.07^*	-1.76	Y_2^d	-2.93^{***}	-3.00
X_2^d	-3.62^{***}	-2.93	X_2^d	-3.18^{**}	-2.39
X_4^d	-1.40^{**}	-1.97	X_4^d	-0.96	-1.39
lnX_2^*	-1.02^{***}	-4.73	lnX_2^*	-0.34^{***}	-3.49
lnX_3^*	0.91^{***}	2.97	lnX_3^*	-0.17	-1.23
lnX_4^*	-0.31^{***}	-2.65	lnX_4^*	-0.08	-0.68
lnX_{2sq}^*	0.05	1.44	lnX_{2sq}^*	0.04	1.07
lnX_{3sq}^*	-0.13^{***}	-2.63	lnX_{3sq}^*	-0.04	-1.40
lnX_{4sq}^*	-0.001	-0.03	lnX_{4sq}^*	-0.01	-0.29
$lnX_2^* lnX_3^*$	0.01	0.25	$lnX_2^* lnX_3^*$	0.01	0.35
$lnX_2^* lnX_4^*$	-0.04	-1.25	$lnX_2^* lnX_4^*$	-0.01	-0.51
$lnX_3^* lnX_4^*$	0.08^{**}	2.41	$lnX_3^* lnX_4^*$	0.03	0.66
lnY_1	0.27	0.55	lnY_1	0.40	1.08
lnY_2	0.86^{**}	2.14	lnY_2	0.93^{***}	3.18
lnY_{1sq}	0.08	1.23	lnY_{1sq}	-0.02	-0.44
lnY_{2sq}	0.13^{***}	2.82	lnY_{2sq}	0.14^{***}	3.37
$lnY_1 lnY_2$	-0.002	-0.17	$lnY_1 lnY_2$	-0.002	-0.12
$lnY_1 lnX_2^*$	0.08^{***}	3.17	$lnY_1 lnX_2^*$	0.003	0.49
$lnY_2 lnX_2^*$	0.01^{**}	2.45	$lnY_2 lnX_2^*$	-0.002	-0.28
$lnY_1 lnX_3^*$	-0.12^{***}	-2.93	$lnY_1 lnX_3^*$	0.01	0.58
$lnY_2 lnX_3^*$	-0.02^*	-1.68	$lnY_2 lnX_3^*$	0.001	0.11
$lnY_1 lnX_4^*$	0.01	0.96	$lnY_1 lnX_4^*$	-0.01	-0.57
$lnY_2 lnX_4^*$	0.00	0.06	$lnY_2 lnX_4^*$	-0.01	-0.90
R_{mf}	0.62^{***}	4.10	R_{mf}	0.28^*	1.87
R_{lf}	1.28^{***}	4.47	R_{lf}	0.84^{***}	2.59
Inefficiency	model		Inefficiency	model	
constant	4.05^{***}	2.62	constant	4.78^{***}	2.64
Education	-3.41^{***}	-3.69	Education	-2.64^{**}	-2.86
Goat Income	-0.63^{***}	-2.95	Goat Income	-2.46^*	-1.95
Southeast	-1.48^{**}	-2.15	Southeast	-25.61^*	-1.69
Northeast	0.18	0.18	West	-0.18	-0.14
Extensive-range	-0.97	-1.01	Extensive-range	-0.30	-0.23
Dry Lot	1.53^*	1.95	Dry Lot	3.49	1.51
Breeding Stock and Show	-2.38^*	-1.79	Breeding Stock and Show	-3.11^{**}	-2.32
Operator Off-farm Job	-1.97^{***}	-2.68	Operator Off-farm Job	-2.17^{***}	-2.67
Organic Production	-0.14	-0.14	Organic Production	2.61	1.63
Gender (female)	-1.68^*	-1.85	Gender (female)	-3.09^{***}	-2.89
Experience	-25.97^{***}	-3.12			

Notes: * 10% level of significance, ** 5% level of significance, *** 1% level of significance.

other variable expense led to increased total fixed expense. Moreover, land use does not have to increase as much to expand the total other variable expense if the total fixed expense level is high. However, the study found that only feed expenses were statistically significant in the U.S. meat goat enterprise model. Interactions between inputs were statistically non-significant in the U.S. meat goat enterprise model analysis.

The output contributions underlying the scale elasticities are also presented in Table 9. The output variable parameters had expected signs in both the whole farm and enterprise models, but only one output measure was statistically significant in both models. The statistically significant productive contribution of all crops and other livestock production (lnY_2) in the whole farm model suggests that increases in all crops and other livestock production increased the productive share or contribution of the land. The statistically significant production contribution of breeding stock production (lnY_2) in the enterprise model suggested that an increase in breeding stock production increased the productive share or contribution of the land. The interactions between meat goat production and all crops and other livestock production ($lnY_1 lnY_2$) outputs in the whole farm model were statistically non-significant, as were the interactions between breeding stock and slaughter stock production in the enterprise model.

The four interactions, $Y_1 lnX_2^*$, $lnY_1 lnX_3^*$, $lnY_2 lnX_2^*$, and $lnY_2 lnX_3^*$ between inputs and outputs, were statistically significant in the meat goat whole farm model. If meat goat production output (lnY_1) and feed expense (lnX_2^*) variables "move together", then increases in lnX_2^* shifted up the share and thus the marginal product of output (lnY_1). Jointness of $lnY_1 lnX_2^*$ implies that the land input use did not have to decrease as much to expand lnY_1 if the lnX_2^* was high. The same conclusion also applies to the interaction between all crops and other livestock and feed expense variables ($lnY_2 lnX_2^*$). However, jointness does not apply to $lnY_1 lnX_3^*$ and $lnY_2 lnX_3^*$. They move in

opposite directions, and increases in meat goat (lnY_1) or all crops and other livestock (lnY_2) output variables shifted down the share or contribution and thus the marginal product of input of the total other variable expenses (lnX_3^*). This indicates the contribution of the land input was increased. The study found that there were statistically non-significant interactions between inputs and outputs in the meat goat enterprise model.

The contributions of medium-sized (R_{mf}) and large-sized (R_{lf}) meat goat operations to productivity were statistically significant relative to small-sized operations (R_{sf}) in both meat goat whole-farm and enterprise models. Elasticity of R_{lf} also confirms that large meat goat farms required the greatest land input share or contribution, with medium-sized farms second in both the whole and enterprise models. This elasticity also showed that the land contribution increased more than two times in magnitude for large-sized operations compared to medium-sized operations in both models.

Estimated inefficiency model parameters for the meat goat whole farm and enterprise models are also presented in Table 9. We found that operator education level, percentage of annual net farm income from the goat operation, Southeast region, percentage of goat sales for breeding stock and show, holding of an off-farm job by the operator, and gender (female) were the efficiency drivers for both U.S. meat goat whole farms and U.S. meat goat enterprises. Farm experience was also an efficiency driver for the U.S. meat goat whole farm analysis. These U.S. meat goat farm/farmer characteristics were statistically significant and contributed to increased meat goat productivity in both models.

Operator off-farm job was significant and increased meat goat whole farm and enterprise technical efficiency as we expected. Most of the meat goat farms were relatively small in scale relative to other livestock farms. Therefore, many meat goat farmers could hold off-farm jobs,

and off-farm income perhaps increases the technical efficiency of meat goat farms as an additional financial resource. This result is consistent with other studies showing that off-farm income or hours worked off-farm by the operator may increase scale and technical efficiency of small-scale operations (Nehring et al., 2009).

The inefficiency model suggests that female meat goat operators were more technically efficient than male operators for the survey data of this study. Note the relative high percentage of female (42%) in this sample who raised meat goats. As we expected, operator education level had a positive impact on and contributed significantly to increased technical efficiency in both models. U.S. meat goat farmers with college degrees were more technically efficient than the farmers with no college degrees. This result is consistent with previous studies on goat and dairy production efficiency analysis that education level was a major factor increasing technical efficiency (Kumbhakar et al., 1991; Ogunniyi, 2010). In addition, Fleming and Lummani (2001) found that more educated cocoa smallholders make better use of information in making decisions and are more open to improved farming methods.

Percentage of net farm income from the goat operation had a positive impact on the technical efficiency of U.S. meat goat farms in both models. This suggested that specialization in meat goat production increased the technical efficiency of meat goat farms. Percentage of goat sales for breeding stock and show was significant and positively related with technical efficiency in both models. Breeding stock and show goat prices are generally higher than slaughter goat prices, though input costs are also higher.

The inefficiency model suggests that a dry-lot production system, where goats are kept in a dry lot with no growing forage and fed purchased feeds and or/hay, was statistically significant and decreased U.S. meat goat farm technical efficiency in the whole farm model. The major

factor driving up costs in the dry-lot production system is feed expense. The results of the regional dummies show that Southeastern region meat goat farmers were more technically efficient than Western region farms in the U.S. meat goat whole farm model. Southeastern region meat goat farmers were more technically efficient than Northeastern region farms in the U.S. meat goat enterprise model. Regional advantages of the Southeast include greater forage availability, lower-cost housing, and climate suitability.

The distribution of the estimated input-oriented technical efficiency scores for both the whole farm and enterprise models are presented in Table 10. The results show that average technical efficiency was 0.84 for U.S. meat goat whole farms. This implies technical inefficiency levels that are 16% on average, or that the average U.S. meat goat farmer could reduce 16% in inputs to produce the same output as an efficient U.S. meat goat whole farm on the frontier.

Table 10. Distribution of the TE for U.S. Meat Goat Farms

| Range of TE | Whole   Farm | | Enterprise | |
	Freq.	% of farms in TE interval	Freq.	% of farms in TE interval
TE <= 0.30	2	1.61	-	-
0.30 < TE <= 0.40	2	1.61	-	-
0.40 < TE <= 0.50	7	5.65	5	4.03
0.50 < TE <= 0.60	3	2.42	4	3.23
0.60 < TE <= 0.70	6	4.84	5	4.03
0.70 < TE <= 0.80	14	5.36	6	4.84
0.80 < TE <= 0.90	26	20.97	17	13.71
0.90 < TE <= 1.00	64	51.61	87	70.16
Total	124	100.00	124	100.00
Technical Efficiency		0.84 (0.17)[1]		0.91(0.14)[1]

Note: [1]Standard deviations for technical efficiencies in parenthesis

The table also shows that more than 72% of the meat goat farmers achieved technical efficiency levels of 80% or higher and about 52% of the U.S. meat goat farms achieved technical efficiency levels of 90% or higher. For the enterprise model, average technical efficiency was 0.91. Thus, for the U.S. meat goat enterprise, producers could reduce about 9% in inputs to produce the same output as an efficient U.S. meat goat producer on the frontier. The table also shows that for the enterprise model, more than 84% of the meat goat producers achieved technical efficiency levels

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of 80% or higher and more than 70% of the U.S. meat goat enterprise producers achieved

technical efficiency levels of 90% or higher. This study also found that the minimum U.S. meat

goat enterprise technical efficiency was greater than 0.40.

The productivity impacts or marginal productive contributions (MPCs) of outputs and

inputs can be evaluated from the first order elasticities of the IDF model (7):

$$MPC_k = -\varepsilon_{D^I Q_k} = -\frac{\partial \ln D^I(X,Q,R)}{\partial \ln Q_k} = \varepsilon_{X_1 Q_k} \text{ and } MPC_m = -\varepsilon_{D^I X_m^*} = -\frac{\partial \ln D^I(X,Q,R)}{\partial \ln X_m^*} = \varepsilon_{X_1 X_m^*}.$$

MPC_k for outputs indicates the increase in overall input use when the kth output expands. MPC_k is

expected to be positive like a marginal cost or output elasticity. MPC_m for inputs represents the

shadow value or the contribution of the mth input relative to X_1 to overall input use. It is

expected to be negative like the slope of an isoquant (Färe and Primont, 1995). All MPCs for

U.S. meat goat whole farm and enterprise analyses had the expected signs, negative for inputs

and positive for outputs, as shown in Table 11. All MPC measures were statistically significant

at the $p \leq 0.01$ and $p \leq 0.05$ percent levels for inputs and outputs, respectively.

Table 11. MPCs of Inputs and Output for U.S. Meat Goat Farms

	Whole farm		Enterprise	
MPCs	Coeff.	t-test	Coeff.	t-test
$\ln X_1$	-0.27***	-4.54	-0.33***	-4.21
$\ln X_2^*$	-0.39***	-6.16	-0.35***	-5.88
$\ln X_3^*$	-0.22***	-3.91	-0.18**	-2.36
$\ln X_4^*$	-0.13***	-2.80	-0.14***	-2.88
$\ln Y_1$	0.39**	2.04	0.30***	2.97
$\ln Y_2$	0.47**	2.40	0.53***	3.23

Notes: **, *** Significances at the 5% and 1% levels, respectively.

The largest MPC in absolute value for inputs was feed expense in both the whole-farm and

enterprise models, indicating that with a unit percent increase in feed expense, the overall inputs

contribution decreased by about 0.39 percent and 0.35 percent for U.S. meat goat whole farms

and enterprises, respectively. The next largest MPC of inputs was for land, followed by total

other variable and total fixed expenses in both models. MPCs for outputs indicate the increase in

overall inputs when output increases. For example, the MPC for lnY_1 suggests a one percent

increases in meat goat production output leads to an increase in overall input usage of 0.39

percent. The same conclusion also applies for the meat goat enterprise that a one percent increase

in meat goat breeding stock production output leads to an increase in overall input usage of 0.53

percent.

Overall economic performance indicators for the meat goat whole farm and enterprise

models are presented in Table 12. In the input distance function, the input-output scale economy

or returns to scale (RTS) relationship represents a sum of the individual output elasticities,

indicating how much overall input use must be increased to support a one percent increase in

overall output. The estimated RTS parameters for the U.S. meat goat farms showed that a one

percent increase in all outputs increased overall input use by 0.86 percent and 0.83 percent for

the whole farm and enterprise production models, respectively. Therefore, an increasing RTS

economy exists in both U.S. meat goat whole farm and enterprise production.

Table 12. RTS, Scope Economies and Scale Efficiency for U.S. Meat Goat Farm

Measurements	Whole Farm		Enterprise	
	Coeff.	t-test	Coeff.	t-test
Returns to scale	0.86***	2.59	0.83***	4.60
Scope economies	0.01	0.17	0.01	0.12
Scale efficiency	1.00***	10.70	1.00***	37.40

Notes: *** Significance at the 1% level.

A measure of scope economies can be estimated with the input distance function (7) by

taking second cross partial output derivatives: $\partial^2 lnD^I(X, Q, R)/\partial lnQ_k \, \partial lnQ_l > 0$. This is not

consistent with the calculation of scope economies from a cost function, where the cost function

measure allows the input variable mix to be adjusted to achieve minimum cost; this calculation,

however, is conditional upon the input mix being held fixed (Coelli and Fleming, 2003).

Therefore, Coelli and Fleming (2003) suggested viewing this scope economies measure as a

lower-bound estimate of the traditional cost function measure of scope economies. The estimated

scope economies or economies of diversification for U.S. meat goat production are presented in Table 10. Denny and Pinto (1978) showed that scope economies exist in the translog functional models if $-\beta_k\beta_l < \beta_{kl}$. This was tested to determine whether scope economies were statistically significant. Scope economies were statistically non- significant in both models. Keep in mind that this estimation results in lower-bound estimates of the traditional cost function measure of scope economies (Coelli and Fleming, 2003).

Scale efficiency is the potential productivity gain from achieving an optimally sized farm. Scale efficiency can also be estimated from an input distance function. The method for estimating scale efficiency was introduced by Ray (1998), Balk (2001), and Ray (2003) from single-output multi-input and multi-output multi-input distance functions. Recently, Nahm et al. (2013) introduced a new method for estimating scale efficiency from a multiple-input, multiple-output parametric hyperbolic distance function. Following Ray (2003), scale efficiency for U.S. meat goat production can be estimated for the IDF (10) as:

$$SEF(X,Q,R) = \exp\left(-(1 - \sum_k \partial lnD^I(X,Q,R)/\partial lnQ_k))^2/2\sum_k\sum_l\beta_{kl}\right) \qquad 4.3.4$$

Scale efficiency in this study is an economic performance indicator representing improvement in average productivity of U.S. meat goat farms through a change in the scale of production. This study found that U.S. meat goat whole farms were, on average, scale efficient if the farms' scale of production was greater than 64 goats or greater than 40 breeding does per operation. From a cost efficiency point of view, on average, U.S. meat goat farms can achieve their lowest long run average cost at greater than 64 or greater than 40 goats and breeding does, respectively, per operation. The study found that on an enterprise-basis, U.S. meat goat producers could be scale efficient if the enterprise scale of production was greater than 58 goats or greater than 38 breeding does per operation.

4.4 MC Simulation Results for SPF Models (U.S. Meat Goat Farms)

This study used hypothetical and empirical Monte Carlo (MC) simulation techniques to illustrate the consistency of small-sample properties of artificial and survey data for SPF models. The SPF was specified as a normal-exponential stochastic production function to deal with the problem of heteroskedasticity. For the hypothetical MC simulation, the study considered the following data generation process (DGP)

$$y_i = 1 + 2x_{1i} + 3x_{2i} + v_i - u_i, \qquad i = 1, \dots, N \qquad (4.4.1)$$

where $v_i \sim N(0, \sigma_{vi})$, $u_i \sim rgamma(1, \sigma_{ui})$, $\sigma_{vi} = \exp(0.5zv_i)$, $\sigma_{ui} = \exp(0.5(1 + 0.5zu_i))$, and both idiosyncratic and inefficiency error scale parameters were a function of a constant term and of an exogenous covariate (zv_i and zu_i) drawn from a standard normal random ($rnormal\ (0,1)$) variable. We used the DGP (4.6) to carry out MC simulation for the SPF model.

The hypothetical MC simulation results are presented in Table 13. The results for β_1 and β_2 and the rejection rates show that there is no significant bias and that the asymptotic distribution approximated the finite-sample distribution well for the DGP with sample of size 250.

Table 13. Hypothetical MC Simulation Results for SPF (U.S. Meat Goat Farms)

Parameters	$\tilde{\beta}$	Std.Dev.	MSE
$\beta_1 = 2$	1.996	0.055	0.095e-6
$\beta_2 = 3$	2.999	0.059	0.031e-8
reject_b_x1	0.004	0.063	
reject_b_x2	0.020	0.140	

We also conducted an empirical Monte Carlo (MC) simulation technique based on the survey data to illustrate the consistency of small-sample properties for SPF models. Again, the SPF was specified as a normal-exponential stochastic production to deal with the problem of heteroskedasticity. For the empirical MC simulation, the following DGP was considered:

$$-x_{1,i} = \alpha_0 + 2y_{1,i}^d + y_{2,i}^d + 2x_{2,i}^d + 3x_{4,i}^d + 2x_{2,i}^* + 3x_{3,i}^* + 4x_{4,i}^* + x_{2sq,i}^* + 2x_{3sq,i}^* + 4x_{4sq,i}^* +$$

$$2x_{2,i}^*x_{3,i}^* + 3x_{2,i}^*x_{4,i}^* + x_{3,i}^*x_{4,i}^* + 2y_{1,i} + 3y_{2,i} + y_{1sq,i} + 2y_{2sq,i} + 3y_{1,i}y_{2,i} + 4y_{1,i}x_{2,i}^* + 3y_{2,i}x_{2,i}^* +$$

$$y_{1,i}x_{3,i}^* + 2y_{2,i}x_{3,i}^* + 4y_{1,i}x_{4,i}^* + 3y_{2,i}x_{4,i}^* + r_{mf,i} + 2r_{lf,i} + v_i - u_i \qquad (4.4.2)$$

where $v_i \sim N(0, \sigma_{vi})$, $u_i \sim rgamma(1, \sigma_{ui})$, $\sigma_{vi} = \exp(0.5zv_i)$, $\sigma_{ui} = \exp(0.5(1 + 0.5zu_i))$, and

both idiosyncratic and inefficiency error scale parameters were a function of a constant term and

of an exogenous covariate (zv_i and zu_i) drawn from a standard normal random ($rnormal$ $(0, 1)$)

variable. This study used the DGP (4.7) to carry out MC simulations for the SPF model.

The empirical MC simulation results for the U.S. meat goat whole farm are presented in

Table 14. The results of the parameters and the rejection rates show that there is no significant

bias and that the asymptotic distribution approximated the finite-sample distribution well for the

DGP with sample of size 124.

Table 14. Empirical MC Simulation Results for SPF (U.S. Meat Goat Whole Farm)

| Parameters | -------- 250 Replications --------- | | | --------- 500 Replications ---------- | | | ------- 1,000 Replications ------- | | |
	Mean	Std.Dev.	Rejection rates	Mean	Std.Dev.	Rejection rates	Mean	Std.Dev.	Rejection rates
b_y^{d}1=2	0.236	12.070	0.044	2.783	11.696	0.022	3.219	12.215	0.015
b_y^{d}2=1	2.569	7.395	0.040	1.481	7.024	0.010	0.910	7.376	0.003
b_x^{d}2=2	3.895	9.567	0.012	3.397	9.607	0.000	2.641	9.536	0.002
b_x^{d}4=3	2.706	4.434	0.004	2.986	4.237	0.006	3.082	4.363	0.001
b_x2=2	1.604	1.597	0.008	1.660	1.444	0.002	1.710	1.387	0.002
b_x3=3	3.690	1.959	0.016	3.557	1.923	0.002	3.570	1.880	0.001
b_x4=4	3.826	0.743	0.012	3.814	0.749	0.008	3.810	0.762	0.002
b_x2sq=1	0.895	0.253	0.052	0.919	0.278	0.030	0.937	0.267	0.015
b_x3sq=2	1.838	0.282	0.016	1.858	0.274	0.006	1.851	0.281	0.004
b_x4sq=4	3.933	0.171	0.024	3.921	0.181	0.008	3.920	0.176	0.002
b_x2x3=2	2.045	0.353	0.028	2.030	0.405	0.012	2.021	0.388	0.001
b_x2x4=3	3.038	0.290	0.016	3.041	0.292	0.012	3.042	0.275	0.001
b_x3x4=1	1.073	0.219	0.028	1.064	0.209	0.010	1.077	0.228	0.005
b_y1=2	1.845	2.946	0.112	2.455	2.941	0.112	2.558	3.077	0.059
b_y2=3	3.405	1.784	0.072	3.172	1.725	0.034	3.026	1.792	0.025
b_y1sq=1	1.036	0.365	0.088	0.957	0.364	0.068	0.943	0.379	0.035
b_y2sq=2	1.939	0.206	0.056	1.965	0.195	0.032	1.982	0.206	0.019
b_y1y2=3	3.011	0.070	0.008	3.013	0.072	0.006	3.010	0.069	0.004
b_y1x2=4	4.049	0.198	0.028	4.046	0.181	0.008	4.042	0.176	0.005
b_y2x2=3	2.988	0.052	0.020	2.992	0.052	0.018	2.987	0.050	0.004
b_y1x3=1	0.924	0.253	0.024	0.942	0.252	0.006	0.942	0.244	0.007
b_y2x3=2	1.997	0.073	0.020	1.990	0.078	0.010	1.995	0.074	0.001
b_y1x4=4	4.002	0.097	0.004	4.002	0.099	0.004	4.002	0.103	0.001
b_y2x4=3	3.010	0.056	0.012	3.008	0.051	0.004	3.001	0.052	0.001
b_mf=1	2.114	0.672	0.052	2.103	0.669	0.020	2.070	0.652	0.009
b_lf=2	4.136	1.403	0.036	4.241	1.270	0.028	4.255	1.290	0.017

We performed 250, 500, and 1,000 MC simulations and obtained parameter estimates, standard errors, and rejection rates of the parameters for the t-test of the null hypothesis for each of the simulation replications (Table 14). We tested whether the parameter estimates were equal to the true parameters (e.g. H_0: $\alpha_8 = 2$). The level or nominal size of the test was set to be $p \leq 0.05$, and t-tests were used. The results from the 250 replications indicate that for the sample of size N=124, the study rejected the null hypothesis for six parameters out of a total of 26 parameters. The results from the 500 replications indicate that for the sample of size N=124, the study rejected the null hypothesis for two parameters out of a total of 26 parameters. Finally, the results from the 1,000 simulations indicate that for the sample of size N=124, the study rejected the null hypothesis for only one parameter out of a total of 26 parameters. Overall, the study showed that empirical MC simulations with 250, 500, and 1,000 replications consistently estimated the parameter estimates and enabled small-sample properties.

The empirical MC simulation results for U.S. meat goat enterprise production are presented in Table 15. The results of the parameters and the rejection rates show that there is no significant bias and that the asymptotic distribution approximated the finite-sample distribution well for the DGP with sample of size 124.

We performed 250, 500, and 1,000 MC simulations and obtained parameter estimates, standard errors, and rejection rates of the parameters for the t-test of null hypothesis for each of the simulation replications (Table 15). We tested whether the parameter estimates were equal to the true parameters (e.g. H_0: $\alpha_8 = 2$). The level or nominal size of the test was set to $p \leq 0.05$, and t- tests were used. The results from the 250 replications indicate that for the sample of size N=124, this study rejected the null hypothesis for five parameters out of a total of 26 parameters. The results from the 500 replications indicate that for the sample of size N=124, this study

rejected the null hypothesis for two parameters out of a total of 26 parameters. Finally, the results

from the 1,000 simulations indicate that for the sample of size N=124, this study rejected the null

hypothesis for only one parameter out of a total of 26 parameters. Overall, this study showed that

empirical MC simulations with 250, 500, and 1,000 replications consistently estimated the

parameter estimates and enabled small-sample properties.

Table 15. Empirical MC Simulation Results for SPF (U.S. Meat Goat Enterprise)

Parameters	# of Replications 250			# of Replications 500			# of Replications 1,000		
	Mean	Std.Dev.	Rejection rates	Mean	Std.Dev.	Rejection rates	Mean	Std.Dev.	Rejection rates
b_y^{d}1=2	3.132	9.741	0.064	3.654	8.311	0.024	3.382	8.782	0.017
b_y^{d}2=1	-0.562	8.957	0.028	0.245	7.862	0.008	0.172	8.490	0.005
b_x^{d}2=2	1.579	8.196	0.004	3.122	7.852	0.000	2.354	7.883	0.000
b_x^{d}4=3	2.096	4.347	0.012	2.919	4.031	0.008	2.877	4.075	0.000
b_x2=2	1.847	0.728	0.008	1.906	0.670	0.008	1.880	0.665	0.003
b_x3=3	3.131	0.890	0.008	3.115	0.833	0.006	3.143	0.811	0.000
b_x4=4	3.925	0.563	0.012	3.996	0.548	0.002	3.987	0.555	0.003
b_x2sq=1	0.960	0.224	0.032	0.925	0.196	0.016	0.942	0.209	0.008
b_x3sq=2	1.922	0.175	0.020	1.940	0.169	0.012	1.935	0.174	0.000
b_x4sq=4	3.937	0.160	0.008	3.923	0.156	0.010	3.923	0.152	0.005
b_x2x3=2	1.988	0.300	0.016	1.998	0.276	0.006	2.002	0.275	0.001
b_x2x4=3	3.036	0.243	0.016	3.039	0.240	0.004	3.044	0.219	0.001
b_x3x4=1	1.052	0.270	0.004	1.044	0.257	0.000	1.044	0.243	0.000
b_y1=2	2.404	2.731	0.136	2.597	2.358	0.082	2.489	2.429	0.046
b_y2=3	2.550	2.571	0.144	2.782	2.258	0.072	2.750	2.419	0.050
b_y1sq=1	0.954	0.373	0.088	0.927	0.322	0.044	0.943	0.330	0.014
b_y2sq=2	2.075	0.349	0.112	2.039	0.308	0.046	2.045	0.328	0.026
b_y1y2=3	2.992	0.047	0.016	2.997	0.046	0.000	2.994	0.049	0.004
b_y1x2=4	4.018	0.059	0.008	4.012	0.056	0.010	4.014	0.057	0.002
b_y2x2=3	3.010	0.054	0.012	3.003	0.053	0.010	3.006	0.050	0.003
b_y1x3=1	1.009	0.104	0.016	1.002	0.098	0.004	1.001	0.105	0.003
b_y2x3=2	1.980	0.091	0.004	1.992	0.091	0.002	1.990	0.084	0.001
b_y1x4=4	3.980	0.081	0.008	3.980	0.076	0.006	3.980	0.077	0.000
b_y2x4=3	3.015	0.046	0.020	3.007	0.053	0.006	3.004	0.048	0.002
b_mf=1	1.979	0.727	0.024	1.970	0.687	0.014	2.002	0.726	0.012
b_lf=2	3.968	1.514	0.032	4.048	1.392	0.030	4.093	1.400	0.010

4.5 IDF Analysis for Southeastern U.S. Meat Goat Farms

The following input distance function was estimated for Southeastern U.S. meat goat

farms using stochastic frontier analysis:

$$- \ln X_{1,i} = \alpha_1 + \varphi_1 Y_{1,i}^d + \varphi_2 Y_{2,i}^d + \varphi_3 X_{2,i}^d + \varphi_4 X_{4,i}^d + \alpha_2 \ln X_{2,i}^* + \alpha_3 \ln X_{3,i}^* + \alpha_4 \ln X_{4,i}^* +$$

$$.5\alpha_5 \ln X_{2sq,i}^* + .5\alpha_6 \ln X_{3sq,i}^* + .5\alpha_7 \ln X_{4sq,i}^* + .5\alpha_8 \ln X_{2,i}^* \ln X_{3,i}^* + .5\alpha_9 \ln X_{2,i}^* \ln X_{4,i}^* +$$

$.5\alpha_{10}lnX^*_{3,i}lnX^*_{4,i} + \beta_1 lnY_{1,i} + \beta_2 lnY_{2,i} + .5\beta_3 lnY_{1sq,i} + .5\beta_4 lnY_{2sq,i} + .5\beta_5 lnY_{1,i}lnY_{2,i} +$

$\theta_1 lnY_{1,i}lnX^*_{2,i} + \theta_2 lnY_{2,i}lnX^*_{2,i} + \theta_3 lnY_{1,i}lnX^*_{3,i} + \theta_4 lnY_{2,i}lnX^*_{3,i} + \theta_5 lnY_{1,i}lnX^*_{4,i} + \theta_6 lnY_{2,i}lnX^*_{4,i} +$

$\delta_1 R_{mf,i} + \delta_2 R_{lf,i} + v_i - u_i$ \hfill 4.5.1

where i = 1, …, 69 is the number of observations and the dependent log variable $ln X_{1,i}$ is the

service flow of the quality-adjusted land value for the ith farm. The input log variables $lnX^*_{2,i}$,

$X^*_{3,i}$, and $lnX^*_{4,i}$ are the values of feed expenses, total other variable expenses, and total fixed

expenses, respectively. For the Southeastern U.S. meat goat whole-farm analysis, we developed

two outputs from the costs and returns data. Output log variables $lnY_{1,i}$[3] and $lnY_{2,i}$[4] are the values

of sales from all meat goats and all other livestock and crops for the meat goat whole-farm

analysis, respectively. For the Southeastern U.S. meat goat enterprise analysis, we also

developed two outputs: $lnY_{1,i}$ is the value of sales from meat goat for slaughter and/or goat meat

and $lnY_{2,i}$ is the value of sales from meat goat for breeding stock. $R_{sf,i}$, $R_{mf,i}$ and $R_{lf,i}$ are dummy

variables for small, medium, and large meat goat farm operations. $R_{mf,i}$ and $R_{lf,i}$ are operation

sizes with 20 to 100 and >100 meat goats, respectively. The base dummy variable, $R_{sf,i}$, indicates

< 20 meat goats on the operation. Interactions between inputs and outputs in the IDF analysis are

also specified. As with the whole U.S. model, outputs and input variables in the IDF may have

zero values. Therefore, we used the dummy variables procedure (4.3.2) to deal with zero

observations like in the whole U.S. model.   The following technical inefficiency effects model

with dependent variable variance of the inefficiency error was estimated for the Southeastern

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[3] We defined output variables as $lnY_{1,i}$ in both Southeastern U.S. meat goat whole-farm and
enterprise.

[4] We defined output variables as $lnY_{2,i}$ in both Southeastern U.S. meat goat whole-farm and
enterprise.

U.S. meat goat farms as a function of farm-farmer characteristics and farm resource regional dummies, as:

$$\sigma_u^2 = \exp\big(\tau_0 + \tau_1 F_{educ} + \tau_2 F_{goatincome} + \tau_3 F_{mp} + \tau_4 F_{fr} + \tau_5 F_{ss} + \tau_6 F_{extrangpast} + \tau_7 F_{drylot} +$$

$$\tau_8 F_{breedstshowsales} + \tau_9 F_{offfarmjob} + \tau_{10} F_{genderf} + \tau_{11} F_{farmexperience} + \tau_{12} F_{sellgm}\big) \qquad 4.5.2$$

where σ_u^2 is the variance of the one-sided error term of u_i, F_{educ} is the farm operator education level dummy (1= bachelor or higher degree, 0 = otherwise), and $F_{goatincome}$ is the percentage of annual net farm income from the meat goat enterprise (1 = $\leq 19\%$; 2 = 20 to 39%; 3 = 40 to 59%; 4 = 60 to 79%; 5 = 80 to 100%). To account for farm region heterogeneity, the Southeastern U.S. was divided into sub-regions as we discussed in Section 3.5. Therefore, F_{mp}, F_{fr}, and F_{ss} are sub-regional dummy variables for the Mississippi Portal, Fruitful Rim, and Southern Seaboard farm resource regions, respectively (F_{eu} is the Eastern Uplands farm resource region considered as the base level). $F_{extrangpast}$ is the goat production system dummy variable for the extensive-range and the pastured but not rotated; F_{drylot} is the dry lot production system. $F_{pastrot}$ is the pastured and rotated production system, which serves as the base level. The extensive-range and the pastured but not rotated production systems are combined. $F_{breedstshowsales}$ is the percentage of goat sales for breeding stock and show. $F_{slaughtothersales}$ is the percentage of goat sales for slaughter or as meat and all other purposes, used as the base category. $F_{offfarmjob}$ is a dummy variable for the operator holding an off-farm job. F_{sellgm} is the "sell goat meat" marketing channel dummy variable to indicate that the meat goat farmer sold goat meat. $F_{genderf}$ is a dummy variable for a female meat goat producer (the base category is a male operator). $F_{farmexperience}$ is a continuous variable indicating the number of years the farmer has raised goats (1 = ≤ 10 years; 2 = $11 - 20$ years; 3 = $21 - 30$ years; 4 = $31 - 40$ years; 5 = ≥ 41 years).

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We used a one-step maximum likelihood method to estimate equations (4.5.1) and (4.5.3) simultaneously. The ML parameter estimates of the translog IDF for Southeastern U.S. meat goat farms, whole farm and enterprise, respectively, are presented in Table 16.

Table 16. The IDF Estimates for Southeastern U.S. Meat Goat Farms

Whole farm			Enterprise		
Variables	Coeff.	t-test	Variables	Coeff.	t-test
constant	1.98	0.61	constant	7.70^{***}	4.55
Y_1^d	4.24^{***}	3.09	Y_1^d	3.47^*	1.88
Y_2^d	-0.17	0.06	Y_2^d	-3.20^{**}	-2.33
X_2^d	-5.83^*	-1.86	X_2^d	1.89	-1.41
X_4^d	-1.73^{**}	-2.33	X_3^d	-0.23	-0.15
lnX_2^*	-1.97^{***}	-7.89	X_4^d	-0.75	-1.12
lnX_3^*	-2.41^{***}	-4.24	lnX_2^*	-0.19^{***}	-2.99
lnX_4^*	-0.30^*	-1.65	lnX_3^*	-0.34^*	-1.89
lnX_{2sq}^*	0.06	0.63	lnX_4^*	0.11	1.10
lnX_{3sq}^*	-0.18^{**}	-2.33	lnX_{2sq}^*	-0.002	-0.05
lnX_{4sq}^*	0.03	0.52	lnX_{3sq}^*	-0.05	-1.58
$lnX_2^*lnX_3^*$	0.18	1.04	lnX_{4sq}^*	0.01	0.28
$lnX_2^*lnX_4^*$	-0.10^*	-1.81	$lnX_2^*lnX_3^*$	0.04	0.96
$lnX_3^*lnX_4^*$	0.10	1.14	$lnX_2^*lnX_4^*$	0.01	0.35
lnY_1	0.94^{**}	2.39	$lnX_3^*lnX_4^*$	-0.03	-0.41
lnY_2	0.48	0.68	lnY_1	0.61	1.33
lnY_{1sq}	0.07	1.31	lnY_2	1.13^{***}	3.07
lnY_{2sq}	0.09	1.19	lnY_{1sq}	0.07	1.10
lnY_1lnY_2	-0.04^*	-1.81	lnY_{2sq}	0.16^{***}	3.31
$lnY_1lnX_2^*$	0.16^{***}	5.07	lnY_1lnY_2	-0.03^{***}	-2.99
$lnY_2lnX_2^*$	0.09^{***}	4.00	$lnY_1lnX_2^*$	-0.02^{***}	-3.47
$lnY_1lnX_3^*$	-0.29^{***}	-3.97	$lnY_2lnX_2^*$	0.00	0.07
$lnY_2lnX_3^*$	-0.04^{**}	-4.00	$lnY_1lnX_3^*$	0.03	1.38
$lnY_1lnX_4^*$	0.02	1.28	$lnY_2lnX_3^*$	0.02	0.91
$lnY_2lnX_4^*$	-0.02^*	-1.77	$lnY_1lnX_4^*$	-0.02^{**}	-2.21
R_{mf}	0.62^{**}	2.53	$lnY_2lnX_4^*$	-0.03^{***}	-3.49
R_{lf}	1.01^{**}	2.35	R_{mf}	0.45^{**}	2.55
			R_{lf}	0.89^{***}	2.93
Inefficiency Model			Inefficiency Model		
constant	13.57^{***}	3.75	constant	17.08^{***}	5.65
Education	-2.00^{**}	-2.71	Education	-2.85^{***}	-3.36
Goat Income	-2.37^{***}	-5.07	Goat Income	-1.90^{***}	-4.45
Mississippi Portal	-2.40	-0.57	Mississippi Portal	-27.71^{***}	-6.00
Fruitful Rim	-4.66^{***}	-3.15	Fruitful Rim	-1.00	-0.89
Southern Seaboard	-3.59^{**}	-2.25	Southern Seaboard	-4.47^{***}	-3.17
Extensive-range	-5.90^{***}	-3.02	Extensive-range	-2.54^{**}	-2.02
Dry Lot	7.21^{***}	5.30	Dry Lot	6.13^{***}	3.13
Breeding Stock and Show	-2.49^{**}	-2.23	Breeding Stock and Show	-6.60^{***}	-4.70
Operator Off-farm Job	-4.68^{**}	-2.48	Operator Off-farm Job	-7.91^{***}	-4.94
Experience	-1.43^*	-1.65	Age	-1.61^{***}	-2.86
Gender (female)	-6.07^{***}	-3.93	Gender (female)	-5.26^{***}	-4.59
Sell Goat Meat	-1.97	-1.44			

Notes: * 10% level of significance, ** 5% level of significance, *** 1% level of significance.

The results of estimated parameters of the Hessian matrix of the second-order partial derivatives with respect to inputs and outputs are found to be negative and positive definite, respectively. These results indicate that the underlining IDF is concave and convex with respect to inputs and outputs, respectively. Individual first-order elasticities characterize input-specific or output-specific contributions and identify the productive contributions of farm or farmer characteristics to production economies (Morrison-Paul and Nehring, 2005).

All input variable parameters for the Southeastern U.S. meat goat whole farm model were statistically significant. These input contributions were somewhat different. The contribution of total other variable (lnX_3^*) and feed (lnX_2^*) expenses were the largest inputs in magnitude, meaning that the increase in total other variable and feed expenses decreased the productive contribution of land ($ln\,X_{1,i}$). The total fixed expense (lnX_4^*) had the smallest contribution in magnitude. The production contribution of total other variable expenses (lnX_3^*) was almost six times larger in magnitude than that of total fixed expenses. Second-order elasticities reflect production complementarities (or biases) that reflect economic performance impacts from output or input jointness (Morrison-Paul and Nehring, 2005). Two input variables, feed and total other variable expenses, were statistically significant in the Southeastern U.S. meat goat enterprise model. Again, total other variable expense had a larger productivity contribution share in magnitude than the feed expenses in the enterprise model.

Only one cross-input variable, feed and fixed expenses ($lnX_2^*lnX_4^*$), was statistically significant in the Southeastern U.S. meat goat whole-farm model analysis. This feed and total fixed expenses interaction was negative, meaning that they were substitutes. This interaction suggests that an increase in feed expense led to a decreased total fixed expense contribution to productivity. Moreover, land use does not have to decrease as much to expand the feed expense

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if the total fixed expense level is high. We found that interactions between input variables were statistically non-significant in the Southeastern U.S. meat goat enterprise model.

The output contributions underlying the scale elasticities are also presented in Table 16. The output variable parameter estimates had expected signs in both the whole farm and enterprise models but only one output was statistically significant in both models. The statistically significant productive contribution of meat goat production (lnY_1) in the whole farm model suggests that increased meat goat production increased the productive share or contribution of the land. The statistically significant productive contribution of meat goat breeding stock production (lnY_2) in the enterprise model suggests that increased meat goat breeding stock production increased the productive share or contribution of land. The output-interactions between meat goat production and all crops and other livestock production (lnY_1lnY_2) and meat goat breeding stock and meat goat and/or goat meat were statistically significant in both Southeastern U.S. meat goat whole farm and enterprise models. The study also found that these interactions were positive, implying their jointness or complementarity. This suggests that an increase in all crops and other livestock production increased the contribution of meat goat production on the whole farm. This also suggests that increased meat goat breeding stock production enhanced the contribution of the meat goat and/or goat meat production in the goat enterprise.

Five interactions, $lnY_1lnX_2^*$, $lnY_1lnX_3^*$, $lnY_2lnX_2^*$, $lnY_2lnX_3^*$ and $lnY_2lnX_4^*$, between inputs and outputs were statistically significant in the meat goat whole-farm analysis. The study found that three input-output interactions, $lnY_1lnX_2^*$, $lnY_1lnX_4^*$, and $lnY_2lnX_4^*$, were statistically significant in the meat goat enterprise model. Contribution of medium sized (R_{mf}) and large sized (R_{lf}) meat goat operations to productivity were statistically significant relative to small-

sized operations (R_{sf}) in both meat goat whole-farm and enterprise models. Elasticity of R_{lf} also confirms that large meat goat farms required the greatest land input share or contribution, with the medium sized farm second in both the whole farm and enterprise models.

Estimated inefficiency model parameters are also presented in Table 16. We found that operator education level, percentage of annual net farm income from goat operations, extensive-range production system, percentage of goat sales for breeding stock and show, operator off-farm job, and gender (female) were the efficiency drivers for both the Southeastern U.S. meat goat whole farm and enterprise analyses. Experience as a continuous variable was included only in the whole farm model. The parameter estimate for experience was statistically significant and increased the technical efficiency of Southeastern U.S. meat goat farms. We included age as a continuous variable in the meat goat enterprise analysis. The parameter estimate results for age showed that it was statistically significant and an efficiency driver in the Southeastern U.S. meat goat enterprise model. Fruitful Rim and Southern Seaboard farm resource regions were statistically significant in the whole farm analysis, and these farms were more technically efficient than those in the Eastern Uplands farm resource region. The Mississippi Portal and Southern Seaboard farm resource regions were statistically significant in the meat goat enterprise analysis. Farms in these two regions were more technically efficient than those in the Eastern Uplands farm resource region.

The dry-lot production system, in which goats are kept in a dry-lot where there is no growing forage and using purchased feeds and or/hay, was statistically significant in both the meat goat whole farm and enterprise analyses, decreasing goat farm technical efficiency.

The distributions of the estimated input-oriented technical efficiency scores for both the Southeastern U.S. meat goat whole farm and enterprise models are presented in Table 17. The

results show that the average technical efficiency was 0.82 for the Southeastern U.S. meat goat whole farm. This indicated that the technical inefficiency level was 18% on average, or that the average Southeastern U.S. meat goat farmer could reduce about 18% in inputs to produce the same output as an efficient Southeastern U.S. meat goat farm on the production frontier. The table also shows that more than 68% of the meat goat farmers achieved technical efficiency

Table 17. Distribution of the TE for Southeastern Meat Goat Farms

	Whole farm		Enterprise	
Range of TE	Freq.	% of farms in TE interval	Freq.	% of farms in TE interval
TE <= 0.10	1	1.45	-	-
0.20 < TE <= 0.30	3	4.35	2	2.90
0.30 < TE <= 0.40	2	2.90	3	4.35
0.40 < TE <= 0.50	5	7.25	0	-
0.50 < TE <= 0.60	4	5.80	4	5.80
0.60 < TE <= 0.70	1	1.45	2	2.90
0.70 < TE <= 0.80	6	8.70	4	5.80
0.80 < TE <= 0.90	8	11.59	2	2.90
0.90 < TE <= 1.00	39	56.52	52	75.36
Total	69	100.00		100.00
Technical Efficiency		0.82 (0.24)[1]		0.88 (0.21)[1]

Note: [1]Standard deviations for technical efficiencies in parenthesis

levels of 80% or higher and about 57% of the Southeastern U.S. meat goat farms achieved technical efficiency levels of 90% or higher. The average technical efficiency in the meat goat enterprise model was 0.88. Thus, the average Southeastern U.S. meat goat farm enterprise could reduce about 12% in inputs to produce the same output as an efficient Southeastern U.S. meat goat farm enterprise on the production frontier. The table also shows that, for the enterprise analysis, more than 78% of the meat goat farms achieved technical efficiency levels of 80% or higher and more than 75% of the Southeastern U.S. meat goat farms achieved technical efficiency levels of 90% or higher. We also found that the lowest Southeastern U.S. meat goat farm enterprise technical efficiency was > 0.20 but ≤ 30.

MPCs for the Southeastern meat goat whole farm and enterprise inputs and outputs had the expected signs, negative for inputs and positive for outputs, as shown in Table 18. MPC

measures for land, feed, and total fixed expenses were statistically significant at the $P \le 0.01$

level in the meat goat whole farm analysis.

Table 18. MPCs of Inputs and Outputs for Southeastern Meat Goat Farms

	Whole Farm		Enterprise	
MPCs	Coeff.	t-test	Coeff.	t-test
$ln\,X_1$	-0.41^{***}	-5.30	-0.32^{***}	-3.20
lnX_2^*	-0.31^{***}	-4.41	-0.31^{***}	-4.58
lnX_3^*	-0.11	-1.02	-0.15^{***}	-2.97
lnX_4^*	-0.17^{***}	-4.13	-0.22^{***}	-2.76
lnY_1	0.42^{**}	2.04	0.32^*	1.72
lnY_2	0.44^{***}	4.09	0.62^{***}	4.97

Notes: $^{**,\,***}$ Significances at the 5% and 1% levels, respectively.

However, the MPC measure for total variable expense was statistically non-significant in the

whole farm model. All MPC measures for outputs were statistically significant in the

Southeastern U.S. meat goat whole farm analysis. MPC measures for land, feed, total other

variable and total fixed expenses were statistically significant at the $P \le 0.01$ level in the

Southeastern U.S. meat goat enterprise analysis. All MPC measures for outputs were also

statistically significant in the meat goat enterprise analysis. The largest MPC in magnitude for

inputs was land expense in both models, indicating that with an increase in the land expense by

one percent, all other inputs contribution share decreased by about 0.41 percent and 0.32 percent

for the meat goat whole farm and enterprise model, respectively. The second largest MPC in

both models was feed, followed by total fixed expense. The overall input contribution share for

meat goat output was 0.42 percent and for all crops and other livestock output it was 0.44 percent

in the meat goat whole farm analysis. This indicated that a one percent increase in meat goat

output increased the overall input share contribution by about 0.42 percent in the whole

Southeastern U.S. meat goat farm model. The overall input contribution share increase was about

0.44 percent for a one percent increase in all crops and other livestock production in the whole

Southeastern U.S. meat goat farm model, on average. However, input shares for meat goat

breeding stock and meat goat and/or goat meat production in the meat goat enterprise analysis

were different in the magnitude. Overall input share increased almost twice as much in the production of meat goat breeding stock relative to meat goats for slaughter and/or goat meat production in the meat goat enterprise. Overall input shares were about 0.62 and 0.32 percent, respectively, for meat goat breeding stock and meat goats for slaughter and/or goat meat production.

Southeastern U.S. meat goat whole farm and enterprise production overall economic performance indicators are presented in Table 19. The estimated returns to scale (RTS) parameter for the Southeastern U.S. meat goat farms showed that a one percent increase in all outputs increased overall input use by 0.86 percent and 0.84 percent for the meat goat whole farm and enterprise production models, respectively. Therefore, an increasing RTS economy exists in Southeastern U.S. meat goat production.

Table 19. RTS, Scope Economies and Scale Efficiency for Southeastern Meat Goat Farms

	Whole Farm		Enterprise	
Measurements	Coeff.	t-test	Coeff.	t-test
Returns to scale	0.86***	4.03	0.84***	5.46
Scope economies	0.14*	1.81	0.12***	2.99
Scale efficiency	1.00***	57.21	1.00***	48.03

Notes: *** Significance at the 1% level.

The estimated scope economies or economies of diversification for the Southeastern U.S. meat goat whole farm and enterprise production are presented in Table 19. The estimated scope economies parameter estimates were statistically significant, indicating that scope economies existed in Southeastern U.S. meat goat production from both whole farm and enterprise perspectives. A coefficient of 0.14 suggests that joint production of meat goat and all crops and other livestock decreased average total cost by 0.14% relative to the separate production of these two outputs on Southeastern U.S. meat goat farm from a whole-farm perspective. A coefficient of 0.12 suggests that joint production of meat goat breeding stock and meat goat for slaughter

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and/or goat meat decreased average total cost by 0.12% relative to the separate production of these two outputs on Southeastern U.S. meat goat farms from an enterprise perspective.

The estimated scale efficiency measures for the Southeastern U.S. meat goat whole farm and enterprise production are also presented in Table 19. We found that, in the Southeastern U.S., meat goat whole farms are, on average, scale efficient if the farm's scale of production is greater than 57 meat goats or greater than 40 breeding does per operation. We also found that from the Southeastern U.S. meat goat enterprise perspective, farms were scale efficient if the enterprise scale of production was greater than 58 meat goats or greater than 39 breeding does per operation. From a cost efficiency perspective, on average, Southeastern U.S. meat goat whole farms and enterprises can achieve their lowest average cost at greater than 57 meat goats or greater than 40 breeding does and greater than 58 meat goats or greater than 39 breeding does per operation, respectively.

4.6 MC Simulation Results for SPF Model (Southeastern U.S. Meat Goat Farms)

We used hypothetical and empirical MC simulation techniques to examine the consistency of small-sample properties of artificial data for SPF models. The SPF was specified as normal-exponential to deal with the problem of heteroskedasticity. For the hypothetical MC simulation, the study considered the following DGP

$$y_i = 1 + 2x_{1i} + 3x_{2i} + v_i - u_i, \qquad i = 1, \dots, N \tag{4.6.1}$$

where $v_i \sim N(0, \sigma_{vi})$, $u_i \sim rgamma(1, \sigma_{ui})$, $\sigma_{vi} = \exp(0.5zv_i)$, and $\sigma_{ui} = \exp(0.5(1 + 0.5zu_i))$, and both idiosyncratic and inefficiency error scale parameters were a function of a constant term and of an exogenous covariate (zv_i and zu_i) drawn from a standard normal random ($rnormal\ (0, 1)$) variable. We used the DGP (4.6) to carry out MC simulations for the SPF model.

The MC simulation results are presented in Table 20. The results for β_1 and β_2 and the rejection rates show that there is no significant bias and that the asymptotic distribution approximated the finite-sample distribution well for the DGP with sample of size 250.

Table 20. Hypothetical MC Simulation Results for SPF (Southeastern Meat Goat Farms)

Parameters	$\tilde{\beta}$	Std.Dev.	MSE
$\beta_1 = 2$	1.996	0.055	0.095e-6
$\beta_2 = 3$	2.999	0.059	0.031e-8
reject_b_x1	0.004	0.063	
reject_b_x2	0.020	0.140	

We also conducted an empirical MC simulation technique based on the survey data to show the consistency of small-sample properties of the survey data for SPF models. Again, the SPF was specified as normal-exponential to deal with the problem of heteroskedasticity. For the empirical MC simulation, the following DGP was considered

$$-x_{1,i} = \alpha_0 + 2y_{1,i}^d + y_{2,i}^d + 2x_{2,i}^d + 3x_{4,i}^d + 2x_{2,i}^* + 3x_{3,i}^* + 4x_{4,i}^* + x_{2sq,i}^* + 2x_{3sq,i}^* + 4x_{4sq,i}^*$$

$$+ 2x_{2,i}^* x_{3,i}^* + 3x_{2,i}^* x_{4,i}^* + x_{3,i}^* x_{4,i}^* + 2y_{1,i} + 3y_{2,i} + y_{1sq,i} + 2y_{2sq,i} + 3y_{1,i}y_{2,i} + 4y_{1,i}x_{2,i}^* + 3y_{2,i}x_{2,i}^*$$

$$+ y_{1,i}x_{3,i}^* + 2y_{2,i}x_{3,i}^* + 4y_{1,i}x_{4,i}^* + 3y_{2,i}x_{4,i}^* + r_{mf,i} + r_{lf,i} + v_i - u_i \qquad (4.6.2)$$

where $v_i \sim N(0, \sigma_{vi})$, $u_i \sim rgamma(1, \sigma_{ui})$, $\sigma_{vi} = \exp(0.5zv_i)$, $\sigma_{ui} = \exp(0.5(1 + 0.5zu_i))$, and both idiosyncratic and inefficiency error scale parameters were a function of a constant term and of an exogenous covariate (zv_i and zu_i) drawn from a standard normal random ($rnormal\,(0,1)$) variable. We used the DGP (4.7) to perform MC simulations for the SPF model.

The whole-farm empirical MC simulation results for Southeastern U.S. meat goat farms are presented in Table 21. The results of the parameters and the rejection rates show that there is no significant bias and that the asymptotic distribution approximated the finite-sample distribution well for the DGP with sample of size 69.

We performed 250, 500, and 1,000 MC simulations and obtained parameter estimates, standard errors, and rejection rates of the parameters for the t-tests of the null hypothesis (Table

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21). We also tested whether the parameter estimates were equal to the true parameters, for example, $H_0: \alpha_{b\_x4} = 4$. The nominal size of the test was set to 0.05, and t-tests were used.

Table 21. Empirical MC Simulation Results for SPF (Southeastern Meat Goat Whole Farm)

Parameters	# of Mean	Replications Std.Dev.	250 Rejection rates	# of Mean	Replications Std.Dev.	500 Rejection rates	# of Mean	Replications Std.Dev.	1,000 Rejection rates
b_y^{d}1=2	4.713	20.398	0.076	2.610	20.961	0.044	1.690	21.764	0.031
b_y^{d}2=1	0.472	21.466	0.100	0.309	22.503	0.046	1.353	23.448	0.022
b_x^{d}2=2	5.040	13.111	0.004	4.240	12.816	0.000	4.256	12.788	0.001
b_x^{d}4=3	3.295	7.304	0.004	3.849	6.899	0.002	3.912	6.811	0.002
b_x2=2	1.162	2.269	0.028	1.431	2.402	0.008	1.635	2.469	0.003
b_x3=3	4.309	3.646	0.040	4.000	3.485	0.006	3.762	3.488	0.000
b_x4=4	3.938	1.427	0.012	3.876	1.447	0.004	3.900	1.410	0.001
b_x2sq=1	0.841	0.485	0.056	0.892	0.469	0.030	0.875	0.451	0.014
b_x3sq=2	1.712	0.481	0.016	1.745	0.438	0.006	1.747	0.460	0.002
b_x4sq=4	3.918	0.315	0.048	3.893	0.295	0.014	3.884	0.290	0.009
b_x2x3=2	2.243	0.689	0.036	2.080	0.717	0.012	2.086	0.670	0.002
b_x2x4=3	3.041	0.395	0.008	3.055	0.415	0.006	3.078	0.422	0.001
b_x3x4=1	1.037	0.450	0.032	1.129	0.455	0.004	1.138	0.420	0.003
b_y1=2	3.153	5.428	0.348	2.562	5.521	0.238	2.250	5.727	0.195
b_y2=3	2.781	5.144	0.300	2.810	5.349	0.174	3.032	5.620	0.149
b_y1sq=1	0.871	0.679	0.244	0.953	0.699	0.128	0.985	0.726	0.085
b_y2sq=2	1.992	0.555	0.252	2.000	0.575	0.164	1.970	0.599	0.110
b_y1y2=3	3.053	0.170	0.032	3.030	0.167	0.004	3.037	0.178	0.000
b_y1x2=4	4.101	0.275	0.048	4.075	0.290	0.012	4.053	0.301	0.001
b_y2x2=3	3.001	0.130	0.024	3.006	0.136	0.000	2.986	0.131	0.001
b_y1x3=1	0.845	0.479	0.064	0.886	0.448	0.030	0.915	0.453	0.017
b_y2x3=2	1.996	0.131	0.020	1.991	0.131	0.004	2.000	0.129	0.001
b_y1x4=4	3.993	0.193	0.024	3.992	0.189	0.002	3.999	0.187	0.001
b_y2x4=3	3.000	0.086	0.024	3.008	0.089	0.002	3.014	0.089	0.004
b_mf=1	1.916	0.995	0.044	1.777	1.038	0.006	1.870	0.986	0.001
b_lf=1	3.890	2.250	0.056	3.645	2.490	0.014	3.675	2.533	0.008

The results from the 250 replications indicate that for the sample of size $N=69$, the study rejected the null hypothesis for nine parameters out of a total of 26 parameters. The results from the 500 replications indicate that for the sample of size $N=69$, the study rejected the null hypothesis for four parameters out of a total of 26 parameters. Finally, the results from the 1,000 simulations indicate that for the sample of size $N=69$, the study rejected the null hypothesis for only four parameters out of a total of 26 parameters. Overall, the study showed that empirical MC simulations with 250, 500, and 1,000 replications consistently estimated the parameter estimates and enabled small-sample properties.

The empirical MC simulation results for Southeastern U.S. meat goat enterprise production are presented in Table 22. The results of the parameters and the rejection rates show that there is no significant bias and that the asymptotic distribution approximated the finite-sample distribution well for the DGP with sample of size 69.

Table 22. Empirical MC Simulation Results for SPF (Southeastern Meat Goat Enterprise)

| Parameters | # of Replications 250 | | | # of Replications 500 | | | # of Replications 1,000 | | |
	Mean	Std.Dev.	Rejection rates	Mean	Std.Dev.	Rejection rates	Mean	Std.Dev.	Rejection rates
b_y^{d}1=2	2.794	13.859	0.096	2.996	13.059	0.056	2.658	13.605	0.036
b_y^{d}2=1	0.848	14.328	0.064	0.120	12.349	0.036	0.280	13.112	0.015
b_x^{d}2=2	0.821	17.010	0.008	2.497	19.068	0.008	1.584	17.674	0.002
b_x^{d}4=3	3.893	7.650	0.016	4.567	7.612	0.004	4.327	7.258	0.000
b_x2=2	1.867	0.884	0.028	1.976	0.946	0.006	1.872	0.898	0.000
b_x3=3	2.911	1.222	0.028	2.962	1.262	0.004	3.063	1.191	0.000
b_x4=4	4.096	0.868	0.020	4.082	0.910	0.006	4.032	0.830	0.002
b_x2sq=1	0.970	0.515	0.136	0.924	0.583	0.064	0.939	0.534	0.032
b_x3sq=2	1.860	0.236	0.048	1.903	0.229	0.008	1.894	0.235	0.000
b_x4sq=4	3.895	0.297	0.072	3.875	0.291	0.038	3.876	0.294	0.011
b_x2x3=2	2.082	0.471	0.020	2.032	0.522	0.006	2.081	0.505	0.001
b_x2x4=3	3.016	0.314	0.020	3.024	0.346	0.006	2.997	0.328	0.002
b_x3x4=1	1.087	0.630	0.056	1.142	0.630	0.008	1.143	0.629	0.001
b_y1=2	2.271	4.155	0.212	2.360	3.934	0.132	2.276	4.110	0.090
b_y2=3	3.230	3.985	0.252	2.977	3.469	0.152	3.013	3.603	0.082
b_y1sq=1	0.979	0.595	0.124	0.970	0.562	0.068	0.975	0.590	0.040
b_y2sq=2	1.970	0.553	0.204	2.012	0.466	0.084	2.007	0.487	0.044
b_y1y2=3	2.984	0.089	0.024	2.977	0.098	0.012	2.982	0.098	0.003
b_y1x2=4	3.994	0.104	0.072	3.987	0.101	0.010	3.989	0.102	0.008
b_y2x2=3	3.018	0.081	0.004	3.001	0.090	0.004	3.020	0.088	0.000
b_y1x3=1	1.054	0.152	0.040	1.043	0.145	0.018	1.036	0.141	0.000
b_y2x3=2	1.982	0.164	0.024	1.984	0.170	0.010	1.972	0.167	0.001
b_y1x4=4	3.959	0.113	0.032	3.959	0.120	0.014	3.967	0.109	0.004
b_y2x4=3	3.011	0.078	0.020	3.001	0.074	0.000	3.009	0.075	0.001
b_mf=1	1.670	1.054	0.028	1.759	1.110	0.018	1.724	1.065	0.006
b_lf=2	2.329	3.753	0.052	2.369	3.950	0.016	2.315	3.981	0.010

We performed 250, 500, and 1,000 MC simulations and obtained parameter estimates, standard errors, and rejection rates of the parameters for the t-test of null hypothesis for each simulation replications (Table 22). We tested whether the parameter estimates were equal to the true parameters, for example, $H_0: \alpha_{b\_x4} = 4$. The level or nominal size of the test was set to 0.05, and t-tests were used. The results from the 250 replications indicate that for the sample of size $N=69$, this study rejected the null hypothesis for eleven parameters out of a total of 26

parameters. The results from the 500 replications indicate that for the sample of size $N=69$, this study rejected the null hypothesis for six parameters out of a total of 26 parameters. Finally, the results from the 1,000 replications indicate that for the sample of size $N=69$, this study rejected the null hypothesis for only two parameters out of a total of 26 parameters. Overall, the study showed that empirical MC simulations with 250, 500, and 1,000 replications consistently estimated the parameter estimates and enabled small-sample properties.

CHAPTER 5: SUMMARY AND CONCLUSIONS

5.1 Summary

Since the early 1990s, meat goat production has been one of the fastest growing agricultural industries in the U.S. The initial interest in meat goat development took place in the Southeastern U.S. states, particularly in Texas. The milestones for meat goat industry growth in the U.S. were organization of the American Meat Goat Association in 1992, which promoted meat goat production; formation of the American Boer Goat Association in 1993, which stimulated meat goat production; repealing of the Wool Act of 1954 in 1993, which resulted in loss of the wool and mohair incentives programs by 1995 and attracted many Angora goat farmers to switch to meat goat production; the tobacco financial settlement, which resulted in an incentive for many tobacco producers, particularly in the Southeast, to enter meat goat production as an economically viable enterprise; and increased immigrant population, which led to increased demand for goat meat.

Given the relative newness of the meat goat industry in the U.S., there has been little empirical research examining the efficiency of U.S. meat goat production. Therefore, the main objective of this study was to analyze the production efficiency of U.S. and Southeastern U.S. meat goat farms. We focus estimation of efficiency on meat goat whole farms and enterprises in both the U.S. and the Southeastern U.S. We examine the economic, socio-economic and other factors influencing the efficiency of U.S. and Southeastern U.S. meat goat production. We also determine and measure scale and technical efficiencies, scope economies, and their underlying output and input composition patterns for U.S. and Southeastern U.S. meat goat production.

This research provides a contribution to the limited empirical literature on the efficiency analysis of meat goat production in the U.S. Meat goats have not been raised extensively in the

U.S.; therefore, studies of livestock production have neglected issues of efficiency of meat goat farms in the U.S. In the U.S., meat goat production has grown rapidly over the last two decades and demand for goat meat has increased significantly. The increasing immigrant and growing ethnic population in the U.S. has been a critical factor in increasing the demand for goat meat. Because of high demand for goat meat, the U.S. has been a net importer of goat meat since 1992. There is an opportunity for farmers to increase meat goat production, especially for small-scale meat goat producers. Moreover, diversifying livestock production, especially for beef cow-calf farms, with meat goat production is the another opportunity. Ultimately, increased goat meat production will help to meet the growing demand for the goat meat in the U.S.

We conducted a nationwide mail survey of U.S. meat goat producers who advertise their meat goat production via the internet for this efficiency analysis. We collected costs and returns data for 2011 expenses from those meat goat producers. This survey was a follow-up to an earlier survey that focused on the marketing, technology, farmer attitudes and farm/farmer characteristics associated with U.S. meat goat production. Since the motivations for the follow-up costs and returns survey were to estimate U.S. meat goat farm efficiency and determine the efficiency drivers, we also used demographics and farm characteristics from the first meat goat survey. We received 142 responses out of a total of 435 meat goat producers who were sent the costs and returns survey. Of those respondents, 107 meat goat farmers completed the survey questionnaire, 17 answered all but a few questions, 5 farmers answered only a few questions, 10 farmers returned the survey because they did not produce meat goat during 2011, one farmer was a sheep producer, and two surveys were undeliverable. We removed farmers from the total survey population who did not produce meat goats in 2011 or who were sheep farmers, as well as undeliverable surveys. Five farmers who answered only a few questions were also removed from

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the total survey population because the responses were not useful for our research analysis. A multiple imputation method was used for the 17 survey responses that were missing a few data points to impute missing information and fully complete those responses. This was because missing data may lead to biased estimates and reduce the efficiency of regression estimates (Rubin, 1987; Schafer, 1997). The follow-up survey had an effective rate of return of 29.7 percent after adjusting for removed responses. Nevertheless, this study had 124 and 69 observations for the efficiency analyses of U.S. and Southeastern U.S. meat goat farms, respectively.

We conducted t-tests to determine whether there were statistically significant differences in means between the first survey and the second survey questionnaires. The results of the t-tests showed that there was not sufficient evidence to suggest the first and the second survey population means were different at P≤0.10 levels.

The sample from the general population of U.S. meat goat farmers showed that the average feed expenses were the largest expenditure among all input expenses not including land. Most meat goat farms, sixty-six percent, had 20 to 100 meat goats in their operations. Twelve percent of the meat goat farms had 100 or more meat goats in their operations. Respondents in the sample had on average some college or a technical college degree. The average total annual net farm income from the goat enterprise was 20 to 39 percent. Most meat goat farmers, fifty-two percent, were resided in the Southeast. The Northeast and the West regions included thirty percent and eighteen percent, respectively, of the meat goat farmers in the sample population. The average U.S. meat goat farms had almost 19 breeding-aged animals on pasture with rotation systems and about 15 breeding-aged animals on pasture without rotation systems. On average,

just over 5 breeding-aged goats were in dry-lot production systems and 7 breeding-aged goats were in the extensive-range or pasture/woods (not handled much) production systems.

The sample population showed that 65 percent of the U.S. meat goat farmers held off-farm jobs. Most respondents reported that their meat goat operations were neither certified organic nor transitioning to organic. Just over four percent of the meat goat farmers were certified organic and /or transitioning. Fifty-nine percent of the respondents were male and 41 percent were female. Meat goat farmers had been raising goats, on average, for 10 years or less. On average, percentage of goats sold by meat goat farmers for slaughter or as meat and breeding stock were 42 percent and 33 percent, respectively. Meat goat producers also sold 17% and 4% of their goats for show and other purposes, respectively.

Summary statistics for Southeastern U.S. meat goat farmers were very similar to those of U.S. meat goat producers. The Southeastern region was divided into four farm resource regions to account for regional differences. In the Southeastern U.S., 54% of the respondent resided in the Southern Seaboard, 29% resided in the Eastern Uplands, 10% resided in the Fruitful Rim, and 7% resided in the Mississippi Portal.

We used the parametric input distance function (IDF) specification for the analysis. The IDF allows for the possibility of specifying a multiple-input and multiple-output technology. We estimated the IDF using stochastic frontier analysis (SFA). We also used a one-step method to estimate the IDF and the technical inefficiency model using the single-step maximum likelihood method. We conducted MC simulation to examine the small sample size properties of U.S. meat goat farms. There is often a concern of lack of statistical representation of a population if the sample size is small, as ours is, with 124 observations. Moreover, there is a concern of

consistency of estimation of the small sample size. Therefore, conducting MC simulation verifies that valid methods of statistical inference are used.

The results from the IDF analysis showed that all input variable parameter estimates were significant for the U.S. meat goat whole farm model. Feed expenses had the largest contribution to productivity; total fixed expenses had the smaller. The total other variable expenses contribution to meat goat whole farm productivity was three times larger in magnitude than that of total fixed expenses. The U.S. meat goat enterprise analysis showed that feed expenses were significant contributors to meat goat enterprise productivity. The U.S. meat goat whole farm model revealed that only one output variable, all crops and other livestock production, had a significant share contribution to the whole farm productivity. We found a significant meat goat breeding stock contribution to the meat goat enterprise in the U.S. Larger meat goat operation sizes were significant production contributors to meat goat productivity in both the whole farm and the enterprise production.

The inefficiency effect models for both whole farm and enterprise revealed that operator education level, percentage of annual net farm income from the goat operation, Southeast region, percentage of goat sales for breeding stock and show, holding of an off-farm job by the operator, farm experience, and gender (female) were the efficiency drivers and improved meat goat productivity in the U.S. The IDF analysis also showed that average technical efficiencies for the U.S. meat goat whole farm and enterprise were 0.84 and 0.91, respectively. The whole farm model showed greater potential to decrease input usage than did the enterprise model in achieving the same output as an efficient farm on the production frontier. We measured marginal productive contributions (MPCs) for inputs and outputs in both the whole farm and enterprise models. Results showed that they were significant with expected signs. We also

measured overall economic performance indicators including returns to scale, scope economies, and scale efficiencies for both models. Increasing returns to scale and scale efficiencies exist in both U.S. meat goat whole farm and enterprise production.

IDF analysis for the Southeastern U.S. meat goat whole farm showed that all input variable parameter estimates were significant. We found that total other variable and feed expenses were the largest contributors to productivity versus the smallest contributor of total fixed expenses to Southeastern U.S. meat goat whole farm productivity. The contribution of total other variable expenses to meat goat whole farm productivity was six times larger in magnitude than that for total fixed expenses. The Southeastern U.S. meat goat whole farm model revealed that meat goat production had a significant share of the contribution to the whole farm productivity. We found a significant meat goat breeding stock contribution to meat goat enterprise productivity in the Southeast. Larger meat goat operation sizes were significant contributors to meat goat farm productivity using both whole farm and the enterprise analyses.

The inefficiency effect models using both whole farm and enterprise models revealed that operator education level, percentage of annual net farm income from goat operations, extensive-range production system, percentage of goat sales for breeding stock and show, operator off-farm job, operator age, experience, and gender (female) were the efficiency drivers for both Southeastern U.S. meat goat whole farm and enterprise analyses. The Fruitful Rim and Southern Seaboard farm resource regions were more technically efficient than Eastern Uplands farms in the whole farm model. However, the Mississippi Portal and Southern Seaboard farm resource regions were more technically efficient than Eastern Uplands region in the meat goat enterprise model. Dry-lot production was an inefficiency driver in both models.

The IDF analysis showed that average technical efficiencies for both the Southeastern U.S. meat goat whole farm and enterprise were 0.82 and 0.88, respectively. Marginal productive contribution (MPCs) measurements for inputs and outputs in both the whole farm and enterprise models were significant except for total other variable expenses, and had expected signs. We also measured overall economic performance indicators including returns to scale, scope economies, and scale efficiencies for both models. Increasing returns to scale, scope economies and scale efficiencies exist on Southeastern U.S. meat goat farms based on both the whole-farm and enterprise analyses.

Hypothetical and empirical MC simulation illustrated the consistency of small-sample properties of artificial and survey data for SPF models. The MC simulation results of the parameters and the rejection rates show that there was no significant bias and that the asymptotic distribution approximated the finite-sample distribution well for the DGP with sample of size 124 and 69 in U.S. and Southeastern U.S. meat goat whole farm and enterprise models. MC simulations and obtained parameter estimates, standard errors, and rejection rates of the parameters for the t-tests of null hypotheses for 250, 500, and 1,000 replications were examined for both the whole farm and enterprise models for U.S. and Southeastern U.S. meat goat production. Overall, we show that empirical MC simulations with 250, 500, and 1,000 replications consistently estimated the parameter estimates and enabled small-sample properties.

5.2. Conclusions and Recommendations

This study revealed that the efficiency of U.S. meat goat farms was impacted by factors such as farm structure characteristics, farmer demographics, and region (location of farms). It also found economic performance measures including increasing returns to scale, scale

efficiency, and scope economies, which exposed insights of efficiency and growth potential for the U.S. meat goat industry. The findings of this study showed:

- The impact of specialization of farm production (percentage of income from the goat enterprise) on meat goat farm technical efficiency is significant. Economies of scope or diversification of farm production was not found for U.S. meat goat production. For meat goat farm productivity growth, specialization in the meat goat enterprise was found to be a potential factor to increase technical efficiency. However, the positive impact of specialization of farm production on meat goat farm technical efficiency in the Southeast was accompanied by an economies of scope measure that was also significant. Thus, while more specialized farms in the Southeast may be more technically efficient, there are scope efficiencies to be gained through diversification.

- The effect of production system on the technical efficiency and productivity of meat goat farms in the U.S. is significant. The extensive-range or pasture/woods production system requires relatively less labor, fertilizer, and capital inputs than pastured but not rotated; however, both systems pasture goats without using management intensive grazing. A management intensive grazing production system, where goats are pastured and rotated, requires additional initial investment and more labor to better manage pasture resources. Dry lot production decreased meat goat farm technical efficiency, requiring additional labor resources, facilities, capital assets, and increased maintenance cost. Generally, farms that used less intensive systems were more technically efficient.

- The effect of targeted market on meat goat farm technical efficiency was significant. While raising goats for breeding stock or show generally involves higher costs relative to goat sales for slaughter or as a meat, returns from goat sales of breeding stock or show

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are also generally higher than those from goat sales for slaughter or as a meat. This study

revealed that operations selling breeding show or stock are more efficient than those

raising goats for slaughter or as meat.

- Off-farm work by producers appears to have a positive impact on technical efficiency,

  perhaps due to the investment of off-farm income on farm operations. Off-farm income

  provides capital for producers to adopt new technologies for the farm, which in turn can

  lead to an increase in farm technical efficiency.

- More highly educated meat goat producers were found to be more technically efficient.

  Farmers with college degrees may have greater ability to adjust to changes as they take

  place in the market.

- Experience, age and gender (female) have impacts on the technical efficiency of U.S.

  meat goat farms. Farmers with more farming experience generally have more knowledge

  about farming practices, which leads to greater efficiency. On the other hand, it can be

  argued that younger farmers are more willing to adopt new technology and apply up-to-

  date production and management practices, which tends to lead to greater technical

  efficiency among younger farmers. The higher technical efficiency of female producers is

  consistent with the relatively large number of female producers in goat production. Forty-

  two percent of the goat farmers in our sample were females. Female ownership of goat

  farms increased by 34% from 1997 to 2002 (USDA, APHIS, 2004).

- Increasing returns to scale (RTS) on U.S. meat goat farms suggests that producers can

  increase the size of their operations, resulting in less overall input usage per unit

  produced. This increasing RTS allows U.S. meat goat farms to realize cost advantages by

expanding their operation sizes. The assertion of this finding is that U.S. meat goat producers are likely to benefit from significant economies of scale.

- Scope economies in Southeastern U.S. meat goat production suggest reduced long run average cost of production via diversification. Scope economies provide Southeastern U.S. meat goat farms with a means to generate operational efficiencies and an economic incentive to diversify production.

- Our results suggest that U.S. meat goat farms can be scale efficient if their optimal size of operation is greater than approximately 64 goats or greater than 40 breeding does.

Overall, the research findings of this study provide significant contributions to the U.S. meat goat industry. The increasing returns to scale finding suggests that the U.S. meat goat industry would benefit from significant increases in farm size. The U.S. Census results suggest the average meat goat farm includes 20 goats; our results show the size of operation that is scale efficient is 60 goats. Furthermore, in the Southeast, scope economies in meat goat production suggest diversification results in decrease total cost.

Results suggest that extension educational efforts will lead to the greater increases in farm technical efficiency if directed to less experienced producers who are full-time farmers, but are diversified across multiple enterprises, those who are raising meat goat for the slaughter market, and those using more intensive production systems.

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U.S. Goat Production Cost and Returns Survey

Throughout this survey, you will be asked questions about your farm production returns and expenses for 2011. Please provide as accurate information to the questions as possible. It is important for the results to truly represent your farm. All information will be kept _strictly_ _confidential_. This is a condition of the grant funding for this project and the Louisiana State University Agricultural Center's Internal Review Board. Thank you!

SALES

1. After subtracting marketing expenses, what was the total dollar value this operation received in 2011 for each of the following crop and/or livestock commodities?

Dollars

   A. Field crops: Corn, rice, sorghum, soybeans, oats, barley, wheat, other grains and oilseeds, dry beans, dry peas, sugarcane, sugarbeets, peanuts, tobacco, cotton, and cottonseed (*Include flaxseed, other grains and oilseeds, popcorn, sunflowers, etc. Exclude sweet corn, silage, and hay.*)…..$_____

   B. Hay and silage…………………………………………………………………………...$_____

   C. Vegetables, fruit, and other crops not included in A and B: Vegetables, melons, potatoes, sweet potatoes, fruit, tree nuts, berries, grass seed, hops, and maple syrup (*Include cabbage, cantaloupes, pumpkins, red beets, sweet corn, tomatoes, watermelons, vegetable seeds, mint, etc.; almonds, apples, blueberries, cherries, grapes, hazelnuts, kiwifruit, oranges, pears, pecans, strawberries, walnuts, etc.*); and nursery, greenhouse, cut Christmas trees, floriculture, and sod (*Include bedding plants, bulbs cut flowers, flower seeds, foliage plants, mushrooms, nursery potted plants, shrubbery, etc.*)………………………………………………………………………………….. $_____

   D. Animals and animal products other than meat goats, goat meat, and beef cattle (*Include sheep, dairy goats and their products, mohair goats and their products, horses, ponies, mules, burros, donkeys, aquaculture, bees and honey, semen and embryo sales, milk, hogs, pigs, chickens, eggs, quail, sheep, etc.*) …………………………………………………………………………………… $_____

   E. Cattle and calves (*Include fed cattle, beef and dairy cull animals, stockers, feeders, veal calves, breeding stock*)………………………………………………………………………… …$_____

   F. Meat goats, excluding breeding stock…………………………………………………. $_____

   G. Meat goat breeding stock…………………………………………………….......... $_____

   H. Goat meat…………………………………………………………………………. $_____

MARKETING CHARGES

2. In 2011, how much was spent by this operation (operators, partners, landlords, and contractors) for marketing and storage expenses incurred by this operation? (*Include check-off, commissions, storage, inspection, ginnings, etc.; and marketing expenses for contract sales.*)………….................$_____

   A. How much of this (*item 2*) was for the meat goat enterprise? .... $_____

OPERATING EXPENSES

3. For this operation in 2011, how much was spent for each of the following items?

   A. Seeds, sets, plants, seed cleaning and treatments, transplants, trees, and nursery stock? (*Include technology or other fees, seed treatments, and seed cleaning costs.*)………................... $_____

B. Nutrients, fertilizer, lime, and soil conditioners? (*Include cost of custom application and organic materials.*) ……………………………………………………………………………………..$_____

C. Biocontrols and agricultural chemicals for crops, livestock, poultry, and general farm use? (*Include pest controls and custom application costs.*)…………………………………………….$_____

D. Livestock purchases of:
   a. Breeding stock for meat goats? ....$_____
   b. Other meat goats? ....$_____
   c. Beef and dairy cattle, hogs, pigs, sheep, dairy goats, goat for mohair, chicken, turkeys, lambs, bees, brooder fish, fingerlings, etc.?...$_____

E. Purchased feed, and, and/or silage for livestock, dairy, poultry, and aquaculture………………..$_____
   a. How much of this (*item E*) was for the meat goat enterprise? ....$_____

F. Bedding and litter for livestock? ....$_____
   a. How much of this (*item F*) was for the meat goat enterprise? ....$_____

G. Medical supplies, veterinary, and custom services for livestock? (*Include artificial insemination, branding, breeding fees, caponizing, castrating, custom feed processing, hormone injections, performance testing, pregnancy testing, seining, sheep shearing, medicine, etc.*)… …………………………..$_____
   a. How much of this (*item G*) was for the meat goat enterprise? ....$_____

H. All fuels, oils, and lubricants? (*Include diesel fuel, gasoline and gasohol, natural gas, LP gas, oils and lubricants, and all other fuel.*)…………………………………………………………………..$_____
   a. How much of this (*item H*) was for the meat goat enterprise? ....$_____

I. Electricity for the farm business? ....$_____
   a. How much of this (*item I*) was for the meat goat enterprise? ....$_____

J. All other utilities and water for irrigation? (*Include the farm share of telephone service, water purchased for irrigation or otherwise, internet access,etc.*)…..$_____

K. Farm supplies, marketing containers, hand tools, and farm shop power equipment? (*Include expenses for temporary fencing. Exclude expenses for bedding / litter and permanent fencing.*)..$_____

L. Repairs, parts, and accessories for motor vehicles, machinery, and farm equipment? (*Include drying equipment, tune-ups, overhauls, repairs to livestock equipment, replacement parts for machinery, tubes, tires, and accessories such as air conditioners, CB's, radios, and hydraulic cylinders. Exclude irrigation equipment and pump repairs.*)………………………………………………………….$_____

M. Maintenance and repair for the upkeep of all farm buildings, land improvements, and all other farm/ranch improvements? (*Include conservation improvements, corrals, feeding floors, feedlots, gravel, land drainage structures, tiling, trench, silos, wells, irrigation equipment and pump repairs and facilities. Exclude any new construction or remodeling.*)…………………………………………………….$_____
   a. How much of this (*item M*) was for the meat goat enterprise? ....$_____

N. Insurance for the farm business? (*Include all casualty insurance, hail insurance, and any other crop of*

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livestock insurance; motor vehicle liability and blanket insurance policies.)……………………..$_____

O. Interest and fees paid on debts for the operation? ....$_____

P. Property taxes paid on farm real estate (land and buildings), livestock, machinery, and other farm production items?..$_____

Q. Renting or leasing of tractors, farm vehicles, equipment, or storage structures? ....$_____

R. Renting or leasing of land for the farm operation? …………………………………………. $_____

    a. How much of this (*item R*) was for the goat enterprise? …………………………………. $_____

S. Farm vehicle and licensing fees? ....$_____

T. Depreciation expense claimed by this operation in 2011 for all capital assets? ....$_____

    a. How much of this depreciation expense (*item T*) was claimed for breeding goats? …............$_____

U. Cash wages paid to hired farm and ranch labor plus payroll taxes and benefits? (*Include cash wages, incentives and bonuses, payments to corporate officers and paid family members including yourself and other operators if they received a wage. Also include expenses for contract labor. Employer's share of Social Security and unemployment taxes; employer's share of health insurance, pension or retirement plans, Workers Compensation, etc.*)……………………………………………………………$_____

    a. How much of this (*item U*) was for the goat enterprise? ....$_____

V. Custom work, performed by machines and labor hired as a unit? (*Include custom grain, livestock, milk, manure, and other custom hauling; and all other custom work including machine hire and machinery and equipment rental.*)……………………………………………………………………..$_____

W. What was the cash value of feed, farm commodities, fuel, housing, meals, other food, utilities, vehicles for personal use, and other non-cash payment for farm work?...$_____

    a. How much of this (*item W*) was in the form of a live goat or goat meat? .... $_____

X. Professional or farm management services such as record-keeping, accounting, tax and business planning, farm product advice, conservation practices, etc.?..$_____

VITA

Berdikul Qushim was born and raised in Samarkand region of Uzbekistan. He received a Diploma in Mathematical Economics from Tashkent Institute of National Economy in 1988. He taught economic classes to undergraduate students at Tashkent State University of Economics. In 1998, Berdikul received a Joint Japan/World Bank Graduate Scholarship to pursue master's degree in economics at Kansas State University. In 2001, he completed his master's program and went back to Uzbekistan. In August of 2007, Berdikul received an assistantship from the Economics Department at Louisiana State University to pursue a PhD degree in Economics. In the Summer of 2009, he transfered to Agricultural Economics and Agribusiness Department to begin the new path to completing his academic career, pursuing a PhD degree in Agricultural Economics at LSU. In August of 2014, Berdikul will be awarded the doctoral degree.