Revisiting Farm Efficiency of Rice-Crawfish Farmers: Accounting for the H-2A Program

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I. Introduction

The production of crawfish is increasing in Louisiana. An increasing demand for crawfish both within the state has incentivized expansion of acreage and production over the last several years.

Figure 1: Crawfish production trend in Louisiana

In addition, an increase in crawfish production is observed as rice producers who are looking to offset struggling rice markets have added crawfish production to their farming operations. In the 2016 growing season, rice producers of Louisiana produced 28.2 million hundredweight (cwt) of rice on 420,821 acres, which accounted an average yield of 66.9 cwt per acre, down from 69.6 cwt per acre reported in 2015. Due to a 13 percent reduction in the rice price from the previous year, gross farm value of the rice crop in Louisiana fell from $361.5 million in 2015 to $305.5 million in 2016. In 2014, farm-raised crawfish production totaled 225,789 acres, which was up 40,000 acres from the previous year. It reached 236,095 acres of land with a gross farm value of $189 million in 2015. In 2016, producers were estimated to
produce 135 million pounds of crawfish, which was up by 2 percent over 2015 and generated
gross farm value of $196 million (Louisiana Summary, 2016).

Rice farming is the main reason for the growth of the crawfish industry over the few
decades in Louisiana. The rice-crawfish farming system started in the 1950s and 1960s. Raising
crawfish in rice fields generated a significant growth for the Louisiana crawfish industry. In
1997, crawfishing generated about $41 million in revenue from 70 million pounds, with $28
million and 47 million pounds of that coming from rice farms. In 2014, the revenue of
crawfishing from rice farms (108.5 million pounds of crawfish) grew to $172 million (Courville,
2016).

In this paper, we examine technical and allocative production efficiency for different
scenarios of H-2A labor utilization in the rice-crawfish production systems employing Data
Envelopment Analysis. We are particularly interested in documenting differences in production
operations that employ the same H-2A workers in both rice and crawfish production vs.
operations that rely on different workers for each production process.

Although the H-2A program is popular among farmers in specific commodities in the
United States, there are very few economic studies related to agribusinesses employing H-2A
workers. The few studies which do exist are mostly descriptive studies and do not offer
inferential economic analysis. There are few studies that focus on H-2A non-immigrant workers
reporting on health outcomes, accommodation and worker adjustment in the working areas
(McCauley, 2005); demand for H-2A workers, labor sourcing and contracting strategies for H-
2A workers (Wu and Guan, 2016); immigration enforcement and impacts on farm profitability
(Ifft and Jodlowski, 2016). Our study will evaluate the role of H-2A workers in the production
system and the results will address the concern of the cost and availability of farm workers for labor-intensive agricultural industries. This will allow us to address heterogeneity of farm structures and the relative utilization of the H-2A program.

An empirical application to crawfish producers in Louisiana is used to illustrate the technical efficiency model. Considering that crawfish can be a rotational crop for rice producers, we collect data from crawfish producers and rice producers. A survey instrument was developed for the purpose of this project. Self-reported data will allow a thorough examination and create a profile of the crawfish industry in the state of Louisiana.

To our knowledge, this is the first study that examines technical and allocative efficiency based on labor management decisions related to H-2A guest workers. The study results will provide insights of efficient use of H-2A workers in multi-cropping systems and could have implications for current H-2A guest worker demand and H-2A program utilization in Louisiana crawfish industry.

The paper is organized as follows. The next section presents a brief overview of the H-2A program and discusses crawfish production and farm efficiency. Section III presents the efficiency model and the variables collected. The last section is discussion of the expected result of the study.

II. Background

H-2A program

The H-2A program originated in 1943 by the U.S. government after giving permission to the United States Sugar Corporation for employing Caribbean workers on temporary visas to hand-cut Florida sugar cane. This program became the H-2 program after it was included as a
subsection in the Immigration and Nationality Act of 1952 (Goldstein, 1997). Historically, the H-2 program was taken as a fraction of the Bracero Program (series of agreements between United States and Mexico for importing manual labor from Mexico to the United States) and focused on the sugar cane and east coast apple production (Wilkinson, 1989). In later years, the H-2 program was separated into agricultural and nonagricultural temporary foreign worker provision H-2A and H-2B programs, respectively, by the Immigration Reform and Control Act (IRCA) of 1986 amending the Immigration and Nationality Act. After the 1986 amendments, employment of H-2A workers expanded to hundreds of tobacco firms in Virginia, cucumber fields in North Carolina, Kentucky, Tennessee, and Connecticut, as well as in other states in a variety of agricultural firms (Goldstein, 1997).

The H-2A program is very effective for some farm owners for securing seasonal low skilled workers for their farm operations. This program connects farm owners and non-immigrant guest farm workers directly and is considered an important immigration policy to alleviate seasonal labor shortages (Badruddozza et al., 2016). As availability of seasonal domestic labor decreased, many seafood producers and crop producers use the H-2A program, with the numbers of H-2A workers reportedly increasing 50% between 2010 and 2014 in the United States (Bronars, 2015). In the southern United States, the diversity of non-immigrant seasonal agricultural and construction labor based in foreign countries has been increasing (O'Sullivan, 2000). The majority of the H-2A workers are young men from Mexico (over 90%) and others originate from South Africa, Peru, Guatemala, Romania, Nicaragua, New Zealand, Costa Rica, El Salvador and Uruguay (Bronars, 2015).

When bringing foreign nationals under the H-2A program to fill agricultural jobs in the United States, agricultural producers are required to submit a temporary labor certification
application to the U.S. Department of Labor (DOL). After receiving temporary labor certification for H-2A employment from DOL, the producer should file an I-129 form with USCIS. After the approval of the I-129 form, prospective H-2A workers who reside outside the U.S. can apply for the H-2A visa. Based on data from the U.S. Office of Foreign Labor Certification (OFLC) 2016 annual report, there were 165,741 H-2A positions certified during the 2016 fiscal year. The number of positions requested for H-2A job visas increased by 18 percent, but there was a 17 percent decrease in the number of certified H-2A temporary employment applications in the fiscal year 2016 over fiscal year 2015. In 2016, more than 2000 positions for H-2A workers were certified for work in 20 states. Of these states, Florida, North Carolina, Georgia, Washington, California, Louisiana, Kentucky, New York, and Arizona had the greatest demand with over 5,000 positions certified for each of these states. In Louisiana, 8,301 H-2A positions were certified in that fiscal year; Baton Rouge (627 positions), Lafayette (588 positions) and New Orleans (556) are the three major cities where H-2A workers were employed. Sugarcane, crawfish, sweet potatoes, nursery and green house, and rice farms were the top five farm types in Louisiana using H-2A labor (OFLC Annual report, 2016).

The H-2A program in its current format has been in existence since 1986. Nevertheless, many U.S. farmers are still unfamiliar with the program and those who are familiar debate over its functionality and efficiency. Higher costs required to hire H-2A workers, the unpredictability in terms of availability of those workers during the peak period of crop season, and administrative burden are some drawbacks of the H-2A program (Wicker 2012). In addition, the bureaucratic burden of advertising, hiring, keeping records, training, and replacing U.S. workers who show limited and short-lived interest in the position are other concerns that growers are
facing (Martin et al., 2013). Several proposals have been introduced in the U.S. Congress to address the labor shortage and simplify the H-2A guest worker program (Fan et al., 2015).

**Rice-crawfish farm and its efficiency**

Crawfish can be produced in monoculture or rotational production systems. In the southeastern United States, crawfish and rice are commonly produced together in an alternative crop rotation system. Production of crawfish in monoculture is commonly found in small farms whereas production of crawfish in a crop rotation system is more typical in larger farming operations (Salassi et al., 2009). In monoculture, crawfish is the sole crop harvested and in multi-crop rotational systems, rice or an additional agronomic crop (e.g. soybeans) is harvested in addition to crawfish (Eversole et al., 2000).

Economic efficiency of the firm is decomposed into technical, allocative and cost efficiency (Farrell, 1957). Technical efficiency (TE) measures the ability of firm to use the available inputs and technology in an effective way. Allocative efficiency (AE) measures the firm’s ability to make the optimal decision on product mix and resource allocation (given input prices). When combining technical and allocative efficiency, cost efficiency (CE) is estimated.

Efficiency can be measured by either parametric or nonparametric methods (T. J. Coelli et al., 2005). In parametric approaches, a stochastic production frontier or stochastic cost frontier is specified and estimated where output or cost is assumed to be a function of inputs, inefficiency and random error. It incorporates the stochastic error that permits hypothesis testing, which is a major advantage of this approach. However, the disadvantage of this approach is that it imposes an explicit functional form and distribution assumption on the error term, which may not be known a priori, and hence result in sizeable efficiency estimation error when assumed.
The most popular of the non-parametric approaches is data envelopment analysis (DEA). It has no prior parametric restrictions on the technology, so it is less sensitive to model misspecification. Similarly, the DEA method is not subject to assumptions on the distribution of error terms and that imposes less assumptions on the production behavior. The estimation through DEA method is based on the piecewise production frontier that makes the estimated frontier very close to the real activity. As DEA is a deterministic approach, all deviations from the frontier are considered as inefficiency, making it sensitive to measurement errors and data noise. Moreover, DEA is known to be sensitive to outliers (Vu, 2007).

Given the advantages and disadvantages of the methods used for estimating technical efficiency, there is no solid and clear reason of using one method over the other (Resti, 2000). However, it has been suggested that the decision for using one of the alternative methods depends on the objective of the study, data availability, and the researcher preference (Wadud et al., 2000). However, Alene et al. (2006) and Bravo-Ureta et al. (2007) reported that general estimated mean technical efficiency from stochastic frontier models are lower than the mean technical efficiency estimated from non-parametric methods and should be considered when contemplating the choice of method.

For establishing the statistical properties of the DEA estimator, bootstrapping can be applied to help overcome some of the disadvantages of the nonparametric method and improve the robustness of the results. Bootstrapping is a method of testing the reliability of a data set by creating a pseudo-replicate data set. For establishing the confidence interval, many studies are including bootstrap in DEA. In particular the bootstrap method is applied empirically in several
studies of farm efficiency in developed countries and it is argued that bootstrapping is the most currently feasible method to establish the statistical properties for DEA estimators (Simar et al., 2000). Brümmer (2001) used the bootstrap to establish the confidence interval of technical efficiency for private farms in Slovenia; Latruffe et al. (2005) applied it for crop and livestock farms in Poland; and Ortner et al. (2006) used it for dairy farms in Austria.

Since DEA is well-suited to the measurement of technical efficiency for multi-output farms (Gocht et al., 2006), this model was chosen for analyzing farm efficiency of Louisiana rice-crawfish farms. DEA is appropriate when the knowledge about the underlying technology is weak (Kalirajan et al., 1999). A major criticism of the DEA approach is that it produces the point estimates of efficiency and these are biased and lack common statistical properties of parametric estimation. However, the bootstrapping method has been developed to estimate the bias and correct efficiency estimates (Abatania et al., 2012). In our case, the bootstrap method is also necessary because we expect a small sample size of farmers growing crawfish and rice in Louisiana.

II. Methodology

This study analyzes the difference in efficiency among the crawfish-rice farmers employing the same H-2A workers in both rice and crawfish farming, and otherwise in Louisiana using a two-stage, semi-parametric approach. DEA is used in the first stage to calculate cost, technical and allocative efficiencies of these two different types of farm operations. Many of the studies of efficiency analysis have used a two-stage approach. In the first stage, DEA is solved and efficiency scores are calculated using only the inputs and outputs. In the second stage, the
efficiency scores are regressed on socioeconomic variables thought to influence efficiency of farms (Coeli, 2005).

In DEA, the efficiency of the farm can be measured using either an input or an output orientation. We adopt an input-oriented DEA approach based on the assumption that cost minimization is a primary goal of producers. When input prices are available, in addition to output and input data, and if cost minimization is the major objective, a measure of cost efficiency can be computed and decomposed into allocative and technical components (T. J. Coelli, Rao, O'Donnell, & Battese, 2005), (Thanassoulis et al., 2008). A fundamental assumption in DEA estimation is that all firms within an industry have access to the same technology, which justifies the estimation of one frontier from the entire data (Zelenyuk et al., 2006).

DEA measures cost efficiency of the firm in two steps. First, given input prices and output levels, the cost-minimizing input vector for the ith farm are calculated using linear programming. Then, cost efficiency is measured as the ratio of minimum cost to observed cost. Let \( y_{ij} \) be an output vector \((r = 1, 2, \ldots, m)\) while \( x_{ij} \) \((i = 1, 2, \ldots, k)\) is the corresponding input vector for each farm \( j \) \((j = 1, \ldots, n)\). Where \( X \) is an ‘\( n \times k \)’ matrix of \( k \) observed inputs, \( Y \) is an ‘\( n \times m \)’ matrix of \( m \) observed outputs for each of the \( n \) farms.

For a target output level \( y_{i0} \) and an input price vector \( w_{i0} \) for farm 0, the minimum cost under the assumption of variable returns to scale (VRS) is obtained by solving the following DEA linear programming problem:

\[
\min \sum_{i=1}^{k} w_{0i} x_{i0}^*.
\]

Subject to:
\[ \sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}^*, \quad i = 1, 2, \ldots, k \]

\[ \sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}, \quad j = 1, 2, \ldots, m \]

\[ \sum_{j=1}^{n} \lambda_j = 1 \]

\[ \lambda_j \geq 1, \quad j = 1, 2, \ldots, n \]

where \( \lambda \) is a \( 1 \times n \) vector of weights and the summation restriction on the elements of vector \( \lambda \) allows for VRS. The optimal solution to this problem is the input vector \( x_{i0}^* \) that minimizes the cost of producing the observed level of outputs given technology and input prices. The cost minimizing input vector, \( x_{i0}^* \), is used to calculate the cost efficiency as (T. J. Coelli, Rao, O'Donnell, & Battese, 2005):

\[ \hat{\delta} = \sum_{i=1}^{k} w_{i0} x_{i0}^* \]

\[ \sum_{i=1}^{k} w_{i0} x_{i0} \]

Cost efficiency (CE) is the ratio of minimum cost to observed cost and takes a value between 0 and 1, where a value of 1 indicates a cost-efficient farm. The CE measures the factor by which the observed cost can be reduced if the ith farm selects the optimal input bundle \( x_{i0}^* \) and operate farm at a technically efficient point.

The input-oriented measure of technical efficiency (TE) of the ith farm under the assumption of variable returns to scale (VRS) is obtained by solving the following DEA linear programming problem:

\[ \min \theta, \]
Subject to:

\[ \sum_{j=1}^{n} \lambda_j x_j \leq \theta x_i \]

\[ \sum_{j=1}^{n} \lambda_j y_j \geq y_i \]

\[ \sum_{j=1}^{n} \lambda_j = 1 \]

\[ \lambda_j \geq 0, \quad j = 1, 2, ..., n \]

The objective of the LP problem is to find the minimum \( \theta \) that reduces input vector \( x_i \) to \( \theta x_i \) while guaranteeing at least the output level \( y_i \). The optimal solution to this LP problem gives \( TE = \theta^* \leq 1 \), where \( \theta^* = 1 \) indicates a point on the efficient frontier and hence a technically efficient farm. \( TE < 1 \) indicates that it is possible to produce the observed level of outputs using less of all inputs.

Once the TE and CE of the farm derived, the allocative efficiency (AE) can be calculated as:

\[ AE = \frac{CE}{TE} \]

**Bootstrapped truncated regression for efficiency determinants**

In most of the early studies of farm efficiency, a Tobit regression model was used in second stage to determine the farm specific attributes for explaining farm inefficiency with varying explanatory variables (T. Coelli et al. (2002); Dhungana et al. (2004); Wadud and White (2000)). Those who use Tobit regression models have justified their approach by explaining the fact that the dependent variable which is farm efficiency of production efficiency estimates have
a censored distribution between 0 and 1 (Thibbotuwawa et al., 2013). However, McDonald (2009) argues that the efficiency scores are not censored, but they are actually functional values. Then he purposes the OLS in a second stage that gives even more consistent results than the Tobit regression. The limitation of the OLS is that the result is consistent only under certain assumptions of the data generating process (Simar et al., 2011). In an earlier paper, Simar et al. (2007) showed that a single bootstrap truncated regression in second stage performs better in terms of estimation of confidence intervals.

Our focus is on the effect of an influential variable which is whether crawfish farmers use the same H-2A labor for rice production as well for crawfish production. This variable is measured and specified in a second stage, single bootstrapped truncated regression in contrast to the general use of Tobit regression to identify efficiency determinants of the farm as Simar and Wilson (2007) follow. The single bootstrapped truncated model is specified as below:

\[
\hat{\delta}_i = z_i \beta + \varepsilon_i \geq 1, \ i = 1,2, ..., n \text{ and } \varepsilon_i \sim N(0, \sigma^2)
\]

where \(\hat{\delta}_i\) is the reciprocal of DEA-estimated cost efficiency such that \(\hat{\delta}_i \geq 1\), \(\varepsilon_i\) is assumed to be distributed \(N(0, \sigma^2)\) with left truncation at \(1 - z_i \beta\), \(z_i\) is a vector of \(k\) other socioeconomic variables which are thought to have an effect on farm efficiency, and \(\beta\) is a vector of parameters to be estimated. As an interpretation rule, a positive coefficient indicates a negative effect on farm efficiency, while a negative coefficient indicates a positive effect on farm efficiency.

**Variables expected from survey**

We compare the farm efficiency of farmers using H-2A labor for crawfish farming only, rice farming only, and in mixed cropping (rice-crawfish). In mixed cropping, our assumption is that farmers may use the same H-2A workers, as long as they do not extend beyond the ten
months of contract, or may use different H-2A workers in each crop production. As a result, the following variables are collected from the survey (survey method is explained in appendix I):

**DEA Variables:** outputs (rice, crawfish), inputs (fertilizers, seeds, pesticides, feed for crawfish, labors etc.), input prices (price for all inputs and wage rates for labor).

**Second stage variables for truncated regression:** farmers using same H-2A workers for producing both rice and crawfish (dummy), access to information proxied by contacting extension agents (dummy), farmers demographic characteristics (age, education, experience), and farm size (small scale and large scale on the basis of acreage).

**Data collection method**

Surveys of all known Louisiana rice-crawfish producers will be conducted to collect data such as total output, inputs required in production process, prices of inputs, farmer's demographic information and, other information. A list of rice and crawfish producers was compiled from the Louisiana State University Agricultural Center, United States Department of Labor, and Louisiana Farm Bureau. Surveys via mail follow the Dillman Tailored Design Method (Dillman et al., 2011) which is discussed in appendix I.

Crawfish producers are asked if they follow the crop rotational system with rice and use the same H-2A workers in both crawfish and rice production. Producers will provide the basic input requirements for the crawfish and rice production process along with the capital cost and labor usage for rice-crawfish farming. This will address the efficiency of crawfish production in a mixed cropping system.
III. Discussion

A positive coefficient of the truncated regression result indicates a negative effect on farm efficiency and a negative coefficient indicates a positive effect on farm efficiency. We expect a negative sign of the efficiency estimate on the truncated regression for the farms where the same H-2A labor is employed in the both rice and crawfish production; efficient use of labor and decreased production cost result in farm efficiency. The number of workers needed on the farm fluctuates seasonally as the level of uncertainty about farm labor demand from the time of planting to its harvest (Taylor, 2010). In case of rice-crawfish farm, more labor is required during the harvesting of crawfish and rice than during the intercultural operations. The harvesting times for rice and crawfish are different seasons of the calendar year, which allows farmers to employ the same workers in both production processes, as long as the period of employment abides by the H-2A program rules. This could reduce the cost of farm production.

Agricultural extension is a medium for transmitting new technologies, effective management options, and better farming practices from researchers to farmers (Owens et al., 2003). In addition to that, agricultural extension also improves the managerial ability of farmers for the effective utilization of existing technologies by improving farmers’ know how (Dinar et al., 2007). In our study, we capture this relation through the respective efficiency estimate. Farmers who frequently meet extension agents will get more training and knowledge to improve the production processes of rice-crawfish management and they know more about new technologies.

Age, education and experience of farmers are factors have a positive impact on the efficiency of the farm. Increase in the farm size results in increases in efficiency because the
labor can be allocated in the large farm with less congestion than in small farm operations and in larger use of other farm inputs is more efficient than in smaller farm.
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Appendix I:

Survey via mail will follow the Dillman Tailored Design Method (Dillman, Smyth, & Melani, 2011) by collecting rice-crawfish producer’s information from available sources such as LSU AgCenter, DOL and, different newsletters. The Dillman Tailored Design Method will be conducted by contacting the producers through first class mail including questionnaire, signed and personally addressed letter on official LSU Agricultural Center letterhead and business reply envelope in the initial phase. The second contact will be a post card reminder one and half weeks later to remind those producers who have not sent back the questionnaire yet and to thank those who have already returned the questionnaire. After the post card reminder, approximately one and a half week later, a third contact will be disseminated using first class mail that will include the second questionnaire which will replace the first in case it was lost. In third contact, producers will be contacted by following a similar way of first communication. The fourth and final contact will be the second post card reminder which will be sent one and half weeks after the third contact. The Dillman Tailored Design Method is applied because by following the similar method, Gillespie et obtained a 41% response rate in survey for the study of beef cattle industry (Gillespie et al., 2007). We expect approximately a 20% response rate for this survey because in a previous survey for the study of crawfish production and marketing of Louisiana crawfish industry, the questionnaire yielded less than 20% response rate from crawfish farmers (Nyaupane et al., 2010). We will simulate the data by using statistical software if response rate is low. The completed sample size needed for desired level of precision can be calculated by following formula:

\[
N_s = \frac{(N_p)(P)(1 - P)}{(N_p - 1) \left( \frac{B}{C} \right)^2 (P)(1 - p)}
\]
Where, $N_s$ = completed sample needed for desired level of precision

$N_p$ = size of population

$P$ = proportion of population expected to choose one of the two response categories.

$B$ = acceptable sampling error

$C$ = $Z$ statistic associated with the confidence level; 1.96 corresponds to the 95% confidence level.