TWO DIMENSIONS OF FARMERS DECISION MAKING ON RECORD KEEPING[1]

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ABSTRACT

To keep physical and financial records about any enterprises is essential if control of the productive process is to be achieved. Some Venezuelan farms belong to commercial systems that keep records (internal information), but a large proportion of farms are managed by farmers who base their performance on familiar knowledge (their own experience), with, little or no concern about systematic record keeping of their activities. Record keeping choice is modeled through a qualitative response model (*probit*) and its impact is evaluated using a production function model. The methodology is refined in order to take full account of the possible presence of self-selectivity problems given the simultaneous equations bias in the production function and probit used in the study. This simultaneous equations system is applied to a sample of 128 pig farmers; and some general conclusions from the study are: farmer experience and farm size (capital investment and stock) are important factors determining farmer propensity to keep records or not. Record keeping choice is an important input that positively influences economic results in the farm. However, keeping physical records has a significantly greater impact on farm output than does keeping financial records.
Key words: records keeping, simultaneous equations, decision making, hog farmer, Venezuela

RESUMEN

Llevar registros de producción y financieros en cualquier negocio es esencial si se busca mejorar el control del proceso productivo. Algunos agricultores venezolanos que poseen sistemas comerciales de producción llevan registros (información interna), pero una buena parte de ellos manejan sus fincas basados en sus conocimientos familiares (su propia experiencia), con muy poca atención a la práctica de llevar sistemáticamente registros físicos y/o financieros de sus actividades. La decisión de levantar registros es modelada a través de una ecuación cuantitativa de respuesta (*probit*) y su impacto es evaluado usando un modelo de función de producción. La metodología es depurada en función de tomar en cuenta la posible presencia de problemas de selectividad individual debido a las desviaciones propias de ecuaciones simultáneas como las usadas en este estudio. Este sistema de ecuaciones es aplicado a una muestra de 128 productores de cerdos. Algunas conclusiones generales del estudio dan cuenta que la experiencia del productor y el tamaño de la granja (capital invertido e inventario) son factores importantes que determinan la propensión de este de llevar o no registros. Así mismo, la decisión de levantar registros es un importante recurso que influye positivamente en el resultado económico de la finca. Sin embargo, llevar registros de producción tuvo un significativo mayor impacto sobre la producción de la granja que los registros financieros.
Palabras clave: levantar registros, ecuaciones simultáneas, toma de decisiones, productor de cerdos, Venezuela

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RÉSUMÉ

Porter des registres de production et de finance dans toute affaire est essentiel si on cherche d'améliorer le contrôle du processus productif. Quelques agriculteurs vénézuéliens qui possèdent des systèmes commerciaux de production portent des registres (l'information interne), mais une bonne partie d'entre eux gèrent leurs exploitations agricoles toute en basons leurs connaissances familières (propre expérience), avec peu d'attention à l'aspect pratique qui concerne systématiquement des registres physiques et(ou) financiers de ses activités. La décision de soulever des registres est modélisée à travers une équation quantitative de réponse (*probit*) et son impact est évalué en utilisant un modèle de fonction de production. La méthode est élaborée en tenant en compte la possible présence éventuelle de problèmes de sélection individuelle grâce aux propres déviations d'équations simultanées telles qu'elles sont utilisées dans cette étude. Ce système d'équations est appliqué à un échantillon de 128 producteurs de porcs; et quelques conclusions générales de l'étude sont : l'expérience du producteur et la taille de l'exploitation (capital inverti et l'inventaire) sont des facteurs importants qui déterminent la propension de celui-ci ou des non registres. La décision de soulever des registres est une ressource très importante qui influe positivement sur le résultat économique de l'exploitation. Cependant, avoir des registres de production, cela a eu un impact significatif sur la production de l'exploitation que les aspectes financiers.
Mots clé: soulever des registres, équations simultanées, prise de décision, producteur de porcs, Venezuela.

1. INTRODUCTION

Management has always been regarded as an important resource in agricultural production, evidencing the Marshallian premise that there are four main factors of production: land, labor, capital, and organization. The latter is the coordinating factor executed by management. It brings together and controls the other factors to make possible the production action. In any business, whatever it is, the manager has the responsibility for making decisions compatible with its growth and progress. Farms are economic organizations that have to make a broad range of decisions. They require sound economic and technical information to make good decisions and implement them properly. The interest of this work is to study the farm management oriented behavior on information recorded (records keeping) for decision making in Venezuelan farms. The culture of not keeping and utilizing records properly is a common place in any agricultural activity in the Bolivarian Republic of Venezuela; and the fact, that some farmers keep records, others occasionally keep records and others never keep records, could be also the general situation in the whole of Latin America. One explanation for this behavior could be that Venezuelan farmers do not have to pay taxes on any agricultural activity they perform. Nevertheless, many farmers in the animal breeding sector (poultry, pig and cattle) keep monthly records on physical and financial statements. Most of them, however, do not efficiently utilize the internal information obtained.

We identify two dimensions of internal information and the users of it, that allows us to analyze the relationship between this information and the decision making act. The first dimension is to understand which factors explain how farmers resolve their internal choice as to whether to keep records or not or why do they avoid such resolutions? The next dimension of this study is an analysis of the economic implications of farming performance as it relates to the level of internal information that is kept. Does the basing of farm management decisions on systematic keeping records, rather than on personal intuition, experience and simple budgeting, lead really to improved farm output?

Before to continue, this short narrative is just to set out the definition of two words commonly used in the decision-making context: decisions and choices. As there are some specific literatures on decision making that make distinctions on their meaning and other literatures treat them as synonymous. When these words are used in this study they have the same meaning; the voluntary act of selecting one possibility from two or multiples of them that which is preferred. Decision or choice requires minimum information to be taken.

Pig farming was the selected case to collect the data required for this study by a survey questionnaire (applied during the 2001-2003 period), whose sample size was formed by 128 farmers. This farming in Venezuela utilizes modern and intensive commercial production systems, with large capital investment, mainly financed by the farmer himself. Even having a modern production system, the average productivity levels found in Venezuelan pig farms is very low compared to that in the U.S., and other surrounding countries such as Brazil. A productivity indicator by channel (kg/animal)

(MAT, 2002) is practically around 60 kg/animal. The low average of productivity has been one of the Venezuelan pig farmer's major problems, although recently, productivity has improved because of the following economic factors brought about by the policies: (1) those small farmers whose production costs became uneconomic left the pig farming business; (2) there has been a conscious effort on the part of some farmers to improve these productivity indicators as a means of lowering production costs; and, (3) those pig farmers that left the pig farming because of the insecurity of the country.

Five basic areas have been considered by the specialists as an explanation about this result: genetic deterioration of their animal breeding stock; poor conditions of pig buildings (Gonzalez and Almonte, 2004); pig feed quality uncontrolled by most of the farmers that do not belong to a vertical integration; low educational level of workers, and, no improvement in the pig farm managers' skills (Viloria, 2005).

2. THE IMPORTANCE OF INFORMATION

Information is an important input for decision making, and it is necessary to concentrate on how it is gathered and evaluated and the relevance of the information. To be in possession of incomplete information is considered, together with externality, market power and public goods, as a factor to explain why markets fail (Samuelson and Nordhaus, 2002).

In a study on «Consumption of Economic Information in Agriculture», Zilberman *et al.* (2002) proposed the following classification of information: (1) A differentiation between data and information. For them, data is an unprocessed characterization on past and present representation of any phenomenon in raw statements of fact; information is the data once it has been processed; (2) A distinction between public and private information provided to a decision maker; (3) The distinction between formal and informal information. They considered that informal information plays a very important role for the decision maker; it is that provided by informal entities and interpersonal networks, and information received from specific institutions or entities, whose functions is to provide information services is considered formal information. Some important conclusions of this research are: (i) Decision makers' with higher levels of formal education (human capital) make little use of formal information channels, in contrast to those with lower levels of human capital use more frequently processed information rather than advertisements or other informal sources; (ii) Future research on information systems must be focused on criteria such as heterogeneity of the information itself as well as the information service entities and users; and (iii) there is a close complementary relationship between senders and users of information, largely based on the disposition of human capital.

In a FAO publication on «Farm Management Research for Small Farmer Development», Dillon and Hardaker (1980) wrote a manual that emphasizes its focus on research methods appropriate for use in small farm studies, in the context of developing countries rather than those designed for developed-country conditions. This paper classifies the information recording on the farm as: physical information, financial information, or both, whole-farm information or records related to a specific aspect of the farm.

Decision makers in the agricultural business face many different types of informational needs and sources. This study considers this information as the facts and details on farming which are received and utilized by the farm manager and so become part of his cognitive process. In any economic activity like the farm business, the dynamics themselves force the creation of some type of control system in keeping with this activity. This control system in some cases is called budgetary control and record keeping (both physical and financial). These control systems can give the manager a detailed current picture of his financial and production situation. Therefore, it is important to introduce here the distinction between: internal information as the registers of technical and economic data on the farmer's own unit; and external information, as any data which is obtained from outside the economic unit, such as data received on technical possibilities, input and output prices, market performance and any other relevant information. When discussing the information for decision-making, we are referring to the internal information gathered and used for the farm business. It includes those physical and financial records that are systematically collected as a result of the farming activities.

Working at farm information, Tomaszewski *et al.* (2000) focus their interest on the use of internal information. These authors try to quantify the benefits of Management Information Systems (MIS) in Dutch dairy farming, and show how the utilization of individual cow production records improved herd performance. The data is non-experimental but consists of several simultaneous time series taken from a random sample of herds for the period 1987-1996. For each year they compared results of MIS users with other herd categories, as follows: «Non-MIS herds in the whole period»; «MIS herds that had not installed the MIS software yet»; «MIS enrolment in the current year»; and «MIS user for more than a year». They used a regression model to analyze the data, where variables such as the average annual amount of milk, feet and protein produced per cow were used as dependent variables, and the effect of the use of MIS was assessed as independent variables. The following explanatory variables were included: 1) the year of particular observation; 2) herd (*e.g. HERD = 1* if observation is of that particular herd and *HERD = 0,* otherwise; which is the kind of «farm dummy» variable; 3) percentage of breed Holstein Friesian, percentage of breed Friesian Holland, number of cows (herd size); 4) *correction = 0*, if observation is of year 1992; *correction = 1*, otherwise; and, 5) the error term. The most important conclusion of this study is that MIS adopters improve their annual milk (carrier) production by 62 kg, protein production by 2.36 kg. per cow and reduce the calving interval by five days.

Respect to the use of Information and Risk Analysis there is a study (Bontems and Thomas, 2000) conducted with the objective to investigate the relationship between the decision on the optimal level of fertilizer to apply assuming farmer risk aversion, and the possibility of processing information. This study used a dynamic, stochastic model of simulation equations to determine sequential choices of alternatives under uncertainty related to a problem of fertilizer application. This study considers there are three sources of uncertainty for the farmers in question namely: the degree of fertilizer leaching, the crop yield, and the output price. The data for this study was taken from the records of the Agriculture Department (USDA) for 1990-1992. These records contain information on harvest, applied nitrogen, applied pesticides and other practices at the plot level. They concluded that risk aversion and value of the information jointly had a weight of 20% of profit per acre in the locality of this study. But the most important finding was that they determined the ability to process the information had a weight that implied about 14$ per acre in relation to risk aversion that implied 2.5$ per acre.

On use of information and consumer awareness, in the study of Teisl *et al.* (2001) the welfare impacts of providing nutrient information to the consumers are sought. The authors consider that there are so many studies on changes in consumer purchase behavior; but their emphasis, besides consumer behavior, was to measure the implication of the difference in information about food quality on population welfare. They used a utility function extended to two different goods toanalyze the data obtained in the late 1980s in an experimental nutrition-labeling programmed. They found that labeling food's nutritional characteristics, along with an informational campaign to educate consumers, could significantly impact on consumer purchase behavior and, therefore, consumer welfare. But they did not find an important statistical relationship between providing food health information and its influence on consumers changing from unhealthy food products to healthier products.

3. EMPIRICAL STUDIES ON FIRM BEHAVIOR

How to define and study farmers' management capacity? is a study of Rougoor *et al.* (1998) where farmer behavior, in terms of managerial abilities, is reviewed through an exhaustive analysis of different textbooks and articles related to this topic. It focused on trying to define and measure management capacity, where this variable is related to having some personal characteristics and skills that make the manager the appropriate person to deal with problems and the opportunities to solve them at the right moment and in the right way. It divides personal characteristics and skills into three groups: (1) drives and motivations, e.g., farmer's goals and attitude to risk; (2) abilities and capabilities, *e.g.*, cognitive and intellectual skills; and (3) biography, *e.g.*, background and experience. Those farmer characteristics and skills are widely used in studies trying to explain differences with respect to the success or failure of a farm.

A functional relationship has been used to study the importance of managerial ability and economies of size in Spanish dairy farms (Alvarez, 2003). Managerial ability is represented by a performance index obtained from a production function; it is then considered as a fixed input in a short-run cost function equation in the second stage of the study. While recognizing that managerial ability is not an easily definable and measurable variable, they probed empirically as to whether or not there is a close association between it and economies of size. However, there is no direct connection between the variables considered in this paper and the variables focused on our paper; it is pointed up because, improving farm managerial ability implicitly means an improvement in the number of techniques in the farming operation, including the practice of record keeping. That is why this article is commented on here.

Regarding the selection of input-output variables to be included in a causative function it is to a «great extent arbitrary», mainly in the case of farm empirical studies, which in a certain sense have to rely on information available when they take place. Thus, in a studymeasuring the association between agricultural productivity and public infrastructure in Greece, private capital stock, labor, intermediate inputs and public infrastructure are included as production inputs in the right hand side of the equations (Mamatzakis, 2003). Land was not considered as an input because this factor has not suffered important changes in the last 40 years in this country. By public infrastructure it considered all public services the farm has to deal with, such as irrigation and electrical facilities, among others.

Another piece of research that calls into question input-output distinction was made by Wilson *et al.* (2001), a study on the farm management characteristic that affects technical efficiency of wheat farmers in eastern England. In this case a stochastic frontier production function is used in the estimation, but, apart from including primary inputs as in a classical production function relationship, it includes personal aspects of the farmer as well as factor inputs in the decision-making process. The amount of grain sold by quality was considered as output; quantity of seed was considered an input along with fertilizer and crop protection products. The labor and machinery were measured by accounting for the number of hours these factors were used. The sets of non-conventional variables included as farm personal characteristics, were considered as a latent variable in the calculation of technical efficient effects in the first stage of the study.

In a study on participation in the off-farm labor market, the decision of small-scale householders in Zimbabwe (Matshe and Young, 2004) has found confirmation of the importance of the household and household properties characteristics such as age, education, productive assets, land area, etc, in making these decisions. The study of Vandermersch and Mathijs (2004) has been an important reference in supporting the selected procedure for our study. According to these authors, the cluster analysis was poor in describing discrete management styles; instead, regression analysis appears to be more successful in delineating some characteristics (not discrete) of managerial attitude that influence financial farm performance. A questionnaire was used for data collection from about 700 farmers as the sample frame for all Flemish dairy farmers of the Farmers Union in Boerenbond (Belgium). It discuss the fact that whereas grouping farms may mask or hide effects especially in heterogeneity within the large groups of farmers; therefore, regression approach allows one to incorporate farmers into the exact range of continuous indicators of which they belong. Using gross margin per 100 liters as dependent variable found that variables such as: importance image and recognition,and independence, have a positive and significant effect as explanatory variables. On the other hand, interest in pedigree breeding and concentrate use and fertility management tuned towards maximizing milk production level has a negative impact on the dependent variable.

4. METHODOLOGICAL FRAMEWORK

The literature suggests that there are many problems generated by individuals making choices of belonging to one group or another as the choice by farmers to keep or not records, which is the key point in this paper. These problems are summarized by the literature on sample selectivity or self-selection problems (Maddala, 1983).

In a research performed by Tambi (2001), a self-selection empirical study of firm behavior model is used as an empirical approach to analyzed factors that are related to household attitudes toward the meat and fish purchase in Cameroon. A simply probit model involving Heckman's two stage procedure has been used to estimate the relationship and to correct for possible selectivity bias.

In another study, Foltz and Chang (2002), tried to describe and to evaluate adoption process of recombinant bovine Somatotropin (rbST) on Connecticut dairy farms, by using Heckman's two-step method rather than random factor. Three models were designed: The first step estimates and evaluates rbST adoption and its impact on milk productivity. The second step takes into consideration that farmers' rbST adoption is done as a sequential event once other technology adoption potentiating the rbST adoption has been taken. Therefore, this model is an augmentation of the first one considering a relationship between rbST adoption and other technology used. Finally, a Tobit model is developed as a third modeling approach in order to evaluate the effect of the intensity of rbST adoption, the percentage of cows treated with rbST on milk yield productivity.

A selection model to evaluate the impact on farm productivity of production contracts was developed by Key and McBride (2003), in the hog sector in the U.S, from 1992 to 1998. The use of contracts by the hog industry has increased in the last decade. It may be given that under contract conditions farmers can reduce some transaction costs that otherwise they would face as being independent farmers. Authors considered as treatment control the differences between farmers who choose whether to contract or not. In this case, many unobservable factors are correlated with both contracting and productivity. Therefore, a sample selection model was used assuming the fact that many of the determinants of farmer contracts decision and farmer productivity are unobservable. Two equations are estimated simultaneously: a probit model of contracts decision and a regression equation of productivity; and a productivity function model that includes, as part of the sets of explanatory variables, the contracting dummy variable that was considered as a dependent variable in the probit model. Using a sample selection model it is assumed that a joint normal distribution exists between the errors terms of the first and the second equations. The production function is used to measure whether farmers can produce more under contract conditions compared to independent producers, holding the rest of the inputs constant. Results of this study revealed that effectively there is a positive relationship between production contracts and farms productivity.

Key and McBride (2003) model is quite similar to the model used for our study on record keeping decision, but in the case of former the treatment effect model is used to model the measure of the effect of contracting on productivity in two ways: (1) the differences in partial and total factor productivity, where Y_i from the production function equation, is a measure of factor productivity; and, (2) the differences in technical progress, where is hog output and is a production function. If contracting is allowed to interact with exogenous variables, then equation is transformed to: where ä is now a vector of parameters associated with the interaction terms.

Treatment models are commonly encountered in empirical research on the evaluation of treatments and social programmed effects. Some of these references are Key and McBride, 2003; Foltz and Chang, 2002; D'Haese *et al.*, 2003. The latter is a research related to farmers' decisions and its impact in their economics' results. It studies the effect of farmers' membership decisions in the local shearing shed association on their revenue. This industrial program is evaluated using treatment effect approach as methodological procedure for the data analysis.

As in others works (*e.g.*, Foltz and Chang, 2002; Matshe and Young, 2004), a priori functional relationship is assumed in this paper, which implies an association between the variable «to keep records», a dummy (binary) dependent variable, and a set of socioeconomics explanatory variables specific to the farmer and his farm. Thus the first causal model used for this study addresses the issue of the farmer characteristics related to farmers' behavior such as being a more systematic manager through keeping records of their farm activities using a probit model (Greene, 2003). For the second research question regarding the impact of keeping records on farm production, a production function is employed that involves the dummy variable on record keeping as an explanatory variable. One of the most popular functional forms used in production function analysis, due to its mathematical simplicity, is the Cobb Douglas equation, having already recognized its limitations in terms of the assumption of fixed returns to scale and the unitary value of the elasticity of substitution coefficient.

The probit model to estimate farmer record keeping decision is as follows:

$$Y_j = \alpha_j + \beta_j \sum_{n=1}^{s} X_{js} + \varepsilon$$

Where Y_j is a vector of binary variables, such that $Y_{j.} = 1$ if the j^{th} farmer chose to keep records on his farming activity, and 0 otherwise; X_{js} are vectors of s explanatory variables of the j^{th} farmer. It is assumed that X_{js} is independent of the zero mean random variable. In the specific case of this study, the empirical model estimated is as follows:

$$Y_j = \alpha_j + \beta_1 E_x + \beta_2 Ed + \beta_2 Stock + \beta_2 Cd + \varepsilon_j$$

Where: Y_j is the dependent variable (*RK*); E_x is the time spent being a pig farmer; *Ed* is the formal education level that the farmer has achieved; *Stock* is measured by ranges of number of sows, it means that according to the number of sows by farm it fall in an specific range; *Cd* is the capital investment in the farm during the last ten years; and ϵ_j represents the error term or random disturbance.

The general empirical Cobb-Douglas model for this study is as follows:

$$\ln(Q)_j = A + \delta_{j1}(RK) + \alpha_{xj2}\ln(lab) + \beta_{xj3}\ln(capital) + \gamma_{xj4}\ln(feed) + \varepsilon_j$$

Where: *Q* is the output, which is considered for this study as the sum of the weight of live pigs fattened (in kg), and the weight of pigs ready for the market by farm at surveying times; *RK* is the index of record keeping choice; lab is the number of workers during the current production year; *Capital* represented by the capital participation in the production process by depreciation measuring, that is counted by the depreciation of the buildings and animal housing; *feed* represents the materials and supplies counted by the amount of feed used per pig cycle of production; ϵ_j is the error term; $\alpha, \beta, \gamma, \delta$ are the estimated parameter coefficients for this equation.

It is necessary to address now the potential self-selectivity problem that is commonly encountered in this kind of research. An attempt is made to establish a link between the level of pig production and the choice by farmers to keep or not to keep records by estimating simultaneous equation models. It may, however, be the case that a farmer who decides to keep records is also intrinsically more productive than a farmer who does not. In other words, farmers may be «self-selecting» themselves into the «keep or not keep records» categories, instead of being randomly assigned. In this case, the parameter estimated attached to the «keep/not keep records» variable may overstate the effect of keeping records, since the farmers who keep records are also intrinsically more productive. Therefore, an adjustment is needed to production-function regression equation, to ensure that the effect of keeping records is properly captured; this is called correction for selectivity bias.

For the case analyzed in this paper, producers choose to keep records in the first stage probit model analysis, then, the decision to keep records variable is included as an explanatory variable in the second stage production function equation. This model, where the (categorical) decision variable appears explicitly as an independent variable in the second stage (production function) regression is commonly referred to as the «treatment» effects model or a two decision model. This is explained below.

$$Q_j = f(X_j) + cRK_j + \varepsilon_j$$

$$RK_j = aW_j + u_j$$

$$RK_j = 1; if\ RK_j^* > 0; and\ RK_j = 0; if\ RK_j^* < 0$$

Here u_j and ϵ_j have a bivariate normal distribution with zero means and correlation ó; (X_j) is a vector of explanatory variables or inputs, and W_j is a vector of observable variables (age, experience, level of education).

In this case, the production function equation with a dummy variable for record keeping appears in the first line. The second and third lines describe the process by which individual producers belong to keep or not records categories. *RK* is thus clearly an endogenous variable. The question is if the production function above is estimated separately in the usual fashion (with no recognition of the selectivity problem), does the parameter «*c*» indicate the value of record keeping? The answer is no if those who decide to keep records would also be highly productive farmers regardless of whether they kept records. Unfortunately, there are many unobservable factors that are correlated with both the decision to keep records and farms' output. Some literature as, *e.g.* Fuglie and Bosch (1995) and Maddala (1986), mention that these unobservable factors are given individual heterogeneity, or individual characteristics not captured by the observed variable.

When this is the situation, simply estimating the production function regression equation on exogenous factors and record keeping decision will result in biased parameters. The ordinary least squares estimate of «*c*» would then overestimate the effect of keeping records. This is the self-selection problem in the treatment effects model (Greene, 2003; Maddala, 1983). In this case, a sample selection model was used for self- selectivity corrections, assuming the fact that many of the determinants of farmer decision in keeping records and farmer productivity are unobservable. This procedure has been implemented for this study using *LIMDEP* software (Greene, 2002), that provides «selectivity-free» estimates of the production function-record keeping relationship.

5. EMPIRICAL IMPLEMENTATION AND RESULTS

5.1. CHOOSING EXPLANATORY VARIABLES AND COLINEARITY

A general empirical probit model was used as one of the preliminarily criteria to choose variables to be incorporated in the econometric analysis. First, a simple probit equation was calculated to see the relationship between each item considered in the survey with the dependent variable to keep records or not. A set of 80 items drawing from each part of the survey were considered in this preliminarily procedure. Second, taking in account the cross-tabulations and the simple probit equation outputs, 33 items were selected from the 80 of the survey. These would be included in a multiple probit equation. This equation represents a poorly identified model, but the idea of using this number of multiple explanatory variables is to start with the largest subset of the possible «explanatory variables X_i», to see their behavior conjointly in terms of evaluating colinearity between the variables. The «Condition number» of the elements of the matrix included in the multi probit equation was used as a criterion to evaluate colinearity (Greene, 2003).

5.2. THE CHOICE TO KEEP RECORDS: PROBIT MODEL

The selected explanatory variables finally used in the general probit model are described in Table Nº 1. Two probit models have been estimated based on the sample data. Given that any kind of recording system, whether for cash, profit, capital, animal birth or feed control, and so on, belongs to two main groups of record systems: physical and financial notation (Dillon and Hardaker, 1980; Jobes and Steward, 1987). Regarding this issue the response to the question on whether to keep records is divided in two subcategories: physical and financial records. According to this characterization of the data regarding the response to the question: whether to keep physical records, and whether to keep financial records, a probit model I on keeping physical records and a probit model II on keeping financial records were estimated respectively.

Maximum Likelihood estimation methods are used to calculate the parameters, the value of which can be found in Table Nº 2. In the *Chi²* test the output of a likelihood function is being tested with the hypothesis that all model parameters, except the constant term of the equation, are zero. The significance level of the test indicates that the null hypothesis can be overwhelmingly rejected. Thus, there is some support for the overall model specification (Greene, 2002).

Table Nº 2 shows the results from the test of the null hypothesis that the parameter estimates equal zero:

Table 1

Description of the variables included in general *probit* model		
Variable acronym	**Variable meaning**	**Type of measure**
Ex	Experience being pig farmer	Categories/ years (from 1 to 5)
Ed	Level of formal education	Categories/levels
Stock	Stock level/number of sows	Categories/No of sows
Cid	Investment made	Dummy response

Source: Own elaboration.

Table 2

Binomial *probit* model I: Keeping physical records			
Variable	**Coefficient**	**Standard Error**	**P value**
Constant	0.322	0.838	0.70005
Ex	-0.393	0.181	0.0297
Ed	0.762	0.148	0.6070
Stock	0.385	0.176	0.0294
Cid	1.559	0.447	0.0005

Source: Own elaboration.

Ho: $\beta_j = 0$; and the *p value* represents the significance level over which the null hypothesis would be rejected.

The first coefficient of the probit model I represents the constant term, which is the expected value of Y_j when all of the independent variables are equal zero. The data for the independent variables are not continuous but categorical. The predicted values of change with units with each time a case fall into any specific category. «Units» in the case of a dummy variable means participation or non participation in the designate category. Thus, due to the categorical nature of the data, we restrict ourselves to the (qualitative) direction of the effect of the independent variables on keeping records.

The first null hypothesis regarding the characteristic of experience (*Ex*) of being a pig farmer is confirmed by the model. It has a significant *p value = 0.0297*, with a negative effect on the probability of the physical records decision. This result has a sensible interpretation because pig farmers with greater experience are more confident with respect to pig handling and control. The more confident farmers tend to rely more on their accumulated knowledge, feeling they can leave aside the collection of internal information to focus efforts on running the farm. Thus, the more experienced pig farmers have a lower probability of keeping physical records.

The effect of the variable education (*Ed)* is not confirmed by the model, since it is not significant at the 5% level. Contrary to expectation, the level of formal education farmers have does not seem strongly to influence the probability of keeping physical records. It appears to have a positive but insignificant effect on the probability of keeping records. For this case study, education does not have a causal effect on the physical record keeping choice. One possible explanation of this result may be that formal education normally received by farmers does not deal with the specific skills required to keep and use physical records for handling pig farms, which may include stock records, births, deaths, weaning, unpaid operators, family labor, among other issues. Therefore, there is no strict link with higher levels of education and farmers' record-keeping choices. Through checking out of literature related to different aspects of farm management, it can be seen that there is a huge and varied field of study dedicated to this topic from different point of view. In a study on transaction cost analysis of outsourcing (part of) farm administration by Belgian farmers (Vernimmen *et al.*, 2000) found that the high level of education is not an important variable explaining farmer's probability of outsourcing. The authors of this study suggest that one explanation for this result may be because there is no connection between the knowledge achieved in the formal educational institutions and the skills required for farm management. Other results from this study indicate that variables as: farmer's age, farm size and institutional environment are important variables explaining of outsourcing farmer's behavior. We can see that number of literature treating on adoption topic recognize that education variable is one of the most important explaining new technology adoption; in spite of that, in the study on the adoption of intensive monocrop horticulture by Cameroon households, Gockowski and Ndoumbe (2004) found that even though education was greater within household in the adopters' group, it did not appear to influence the monocrop adoption probability.

The third null hypothesis regarding stocking level (*Stock*) given by the range in number of sows, is confirmed by the model (*significant at 5% level*). This variable is related to the farm size characteristic, whose coefficient appears to have a positive function in respect of the choice of keeping physical records. This means the greater the number of sows a farmer has on his farm, the greater the probability of keeping physical records. This result is logical because the more complex farms are in terms of production scale, the better the managerial skills needed. There is, therefore a higher probability of farmers attempting to keep physical records for better animal control and so on. As checked in some review of literature like (Alvarez, 2003; Rougoor *et al.*, 2000), it is not a surprise to find a strong relationship between the scale of the business and managerial abilities or managerial tools required to operate it.

The fourth null hypothesis is regarding capital investment (*Cid*) done in the farm during the last ten years. This might have included animal housing enlargement and renovation, buying sows and/or pedigree boars, among others. This variable has a highly significant impact on the decision to keep physical records at the *5% level*. The *Cid* coefficient value is positive, which means that as investment increases into the farm, the larger the probability that the farmer keeps physical records. This is another variable regarding farm size characteristics like the stock variable. This result also makes sense, because the more investment farmers have made in their farms, the more commitment they feel to take care of this investment by being more systematic as managers, keeping physical records.

Coefficients of probit II (financial record keeping) give us the following results: The coefficient of determination adjusted, R^2 is 0.536, which measures the goodness of fit. This is an acceptable result just as in probit model I. According to the results, the model is able to predict 89.77% of the total cases correctly. From the non adopters (zero responses) it predicts 76%, and 94% in the case of the adopters (one response).

Maximum Likelihood methods were again used to determine the parameter estimates. The Chi^2 test statistic relating to the null hypothesis that all independent variables are jointly insignificant shows once again the null hypothesis is rejected strongly over the model specification.

As we can see in Table Nº 3, the first null hypothesis regarding the characteristic experience (*Ex*) of being a pig farmer is nearly confirmed by the model. Its *p value = 0.0701* shows significance at the 10% level though not at the *5% level*. However, the coefficient value is negative. This result is also understandable because expertise can motivate farmers to leave aside totally the effort of keeping physical records (probit I); but in the case of probit II equation, because of the nature of financial records, it implies a more complex arrangement, give it requires a more formal and complicated accounting system, reporting income and expenses of the business, it is not as easy leave aside the job of keeping financial records. Moreover, the kind and amount of information farmers can manage keeping financial records is, in a certain sense, a connection between the farm system and the market. Therefore, expert pig farmers may have to be more careful in terms of deciding do not to keep financial records at all on their economic activities. They may feel tempted to leave aside the work of keeping financial records, but not in such a determined fashion as tested in probit model I. That could be the explanation on this slightly insignificant *p value* result observed in probit model II.

The second parameter, regarding the characteristic of level of education (*Ed*), is once again positive but insignificant. The same argument as in probit I may apply here.

Table 3

Binomial *probit* model II: Keeping financial records

Variable	Coefficient	Standard Error	P value
Constant	-1.109	0.843	0.1886
Ex	-0.373	0.206	0.0701
Ed	0.178	0.161	0.2700
Stock	0.642	0.221	0.0360
Cid	1.839	0.451	0.0000

Source: Own elaboration.

The third null hypothesis is regarding the characteristic of animal *stock levels*. It has a significant *p value*, and the coefficient value is positive. As was expected, and quite similar to the probit model I, as the number of sows owned by farmers' increases, there is a greater probability of pig farmers keeping financial records; thus, there seems to be a robust scale effect in record-keeping.

Regarding the characteristic of capital investment made (*Cid*) in the farm during the last ten years, again this variable has a highly significant *p value* and a positive impact on the dependent variable (*at 5% level*). As more investment is made into the farms, the greater the likelihood of farmers keeping financial records.

5.3. EFFECTS OF RECORD KEEPING CHOICE ON PIG FARM OUTPUT (THE COBB-DOUGLAS PRODUCTION FUNCTION)

Facing the same data arrangement as for the probit model estimations, two Cobb-Douglas production function equations were developed, called production function I and II. Function I corresponds to the response answer to keep physical records and function II to keep financial records.

Production function I: these results show the second stage estimates of the pig production function measured per kg (yield estimates), with Physical records (*PHYRK*) used as the endogenous explanatory variable. This equation has a high adjusted R^2 of 0.782, which is a good fit to the data.

The estimates show that the coefficient of $\ddot{e}_s$ at the bottom of Table N° 4 appears highly significantly different from zero at *0.05 levels*. This means there is evidence of sample selection bias, and confirms the main research hypothesis, that keeping records has a positive impact on pig economic outputs. The choice of keeping physical records appears to have a significant relationship in respect of pig farming output, when yield is selected as the dependent variable; which is in fact, a measure of farmer performance, together other relevant variable. The *PHYRK* coefficient value is positive, meaning that the choice of keeping physical records impacts positively on farmer performance, and the choice of not keeping physical records on pig farm business, otherwise.

As regards the other variables, the following observations are noteworthy: Labor (*Lab*) appears to have a positive and significant impact explaining the variability of the dependent variable pig production, as was expected. As in this case the labor was measured in terms of number of workers contracted and paid throughout a pig production cycle, and is therefore a discrete, but not categorical variable. Thus, the coefficient value of this variable indicates that when this factor increases by 1%, it will increase the output by 0.413%.

Capital (*deprec.*) is the capital depreciation; it represents buildings and animal housing depreciation. It is based on production cost/kg of pigs index from three pig farm production scales in Venezuela, which include building depreciation among other items incorporated in the pig farm costs structure (Promasa, 1990). This index is multiplied against the total weight of animal stock (sow, boars, immature females, lactating sows and weaner) without including in fatteners pigs. It obtains the valuable costs of building depreciation according to the farm scale. Thus, *deprec.* represents the valuable depreciation/kg mature live pigs in the stocks. This variable appears to have the highest significant (*p value = 0.0000*), from the estimated coefficients for this equation, and the coefficient sign is positive, as was expected. This means that a unitary percent increase in the value of depreciation of capital will impact positively on the dependent variable output by a 0.55% of finished pig output.

Table 4

Coefficients estimated. Production function model I by self-selection treatment effects

Variable	Coefficient	Standard Error	P value
Constant	5.395	1361	0.0001
Lab	0.413	0.140	0.0032
Capital	0.555	0.827	0.0000
Feed	-0.295	0.156	0.8504
PHYRK	0.665	0.338	0.0488
Lambda	-0.449	0.203	0.0271

Source: Own elaboration.

Feed includes the intermediate input for the production process, which is measured as total feed kg/ day. It is obtained from the total amount of feed in kg consumed per day by the farm stocks, and calculated for a year. In this case, contrary to that was expected, this variable is insignificant at *0.05 levels*, and the sign of the coefficient is negative. An explanation for these results regarding *Feed* factor in the production function equation could be the inaccurate measuring of these variables because, on one hand, most of the pig farmers surveyed did not have accurate information on the amount of feed used according to the animal growth stages during the year; and, on the other hand, the values obtained for those data simply are the average daily use per type of animal multiplied by 365. It means this total per day is recalculated by the year, without taking into account the differentiations in the fact between type of feed and the age of the animals during a year period.

The results of production function model II are presented in Table Nº 5. It shows that the pig production function per kg estimated (yield estimates), with financial records (*FINRK*), are not quite similar to the production function results with *PHYRK* as the endogenous explanatory variable. This equation has a high adjusted R^2 (0.778), which shows a good fit to the data.

The estimates show that the coefficient of *ë* (at the bottom of Table Nº 5) appears not to be significantly different from zero at the *0.05 level*. There is not sufficient evidence to reject the null statistic hypothesis of no selection bias.

On the other hand, these results shows that keeping financial records (*FINRK*) is not confirmed by the model at the *0.05 level* and it is confirmed by the model at the *0.1 level*. The p *value* = *0.0750* at the *0.05 level* is insignificantly different from zero but close. It is observed that p *value* = *0.075* is about the same as *0.05 level* as a critical point in the statistical test analysis. The coefficient of this variable appears positive. According to this result, keeping financial records slightly affects pig production results.

Regarding the estimation of labor and capital parameters in Cobb-Douglas function II are quite similar to those obtained in the production function I, which is reasonable given that the only different data comes from keeping financial records and the value of *ë* coefficient. As was expected, the factor Labor also appears to have a positive and significant impact on the variability of the dependent variable pig production (with $p = 0.0046$). The coefficient value of this variable indicates that when this factor increases by 1%, it increases by 0.405% the finished pig in the farms.

As in the previous model the capital depreciation *deprec*. represents the depreciation/kg mature live pig in the stock. As was expected, this variable appears to have the highest significant p *value* = *0.0000* from the estimated coefficients for this equation. That means unitarian percent increasing in the valuable depreciation of capital impacts positively on the dependent variable output in 0.548% of finished pig. The intermediate inputs variable *Feed* of the production function II, as in the production function I, does not have a significant impact in pig farm output at *0.05 levels,* and the possible explanations of this result were given previously.

6. CONCLUSIONS

This study focuses on farmers' oriented behavior which related to being a more systematic manager keeping records. This is well explained by the set of simultaneous equations models applied in the self-selection of the treatment effect model specification. Consistent with the literature review on models of production-oriented farming behavior, it has found that models used in this study are good at explaining and predicting farmers' behavior in keeping records.

Table 5

Coefficients estimated: Production function model II by self-selection treatment effects

Variable	Coefficient	Standard Error	P value
Constant	5.698	1.381	0.0000
Lab	0.406	0.143	0.0046
Capital	0.548	0.845	0.0000
Feed	-0.376	0.158	0.8123
FINRK	0.519	0.291	0.0750
Lambda	-0.260	0.200	0.1929

Source: Own elaboration.

Following naturally from the specific findings derived from the results of the estimation of the two equation systems, this can be categorized according to their dependence on the type of records kept (physical or financial) and their specific realizations within each model. We now itemize these specific findings as follows for both equation systems; therefore, for Probit Model I and Production Function I, for Physical Records Answer (*PHYRK*) and Probit Model II and Production Function II, for Financial Records Answer (*FINRK*), by applying a self-selection-by-treatment-effect model indicated the overall specification of the model is satisfactory, and has a great capacity to predict the total cases correctly in 87.5% and 89.7% respectively. The adjusted R^2 in both systems are also satisfactory.

Finally the general conclusions for this study in respect of record keeping are: i) Farmer experience is a factor that negatively affects farmers propensity to keep records; ii) Farm size (capital investment and stock) is an important factor determining farmer propensity to take a recording system on the farm; iii) Record Keeping by farmers is an important input that has a positive effect on farm economic results; iv) Keeping physical records has a higher impact on farm output than keeping financial records; and finally, v) The evidence of sample selection bias was highly significant for the system of equations I (*PHYRK*) and for the system of equations II (*FINRK*) otherwise.

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