

Abstract 025-0184

**Adoption of technological and managerial requirements to export beef to the EU: a  
study of Brazilian farms**

Marcela de Mello Brandão Vinholis

Brazilian Agricultural Research Corporation (Embrapa)

Rod. Washington Luiz, Km 234 – 13.560-970 - São Carlos, SP, Brazil

[marcela.vinholis@dep.ufscar.br](mailto:marcela.vinholis@dep.ufscar.br)

Hildo Meirelles de Souza Filho

Universidade Federal de São Carlos

Rod. Washington Luiz, Km 235 – 13.565-905 - São Carlos, SP, Brazil

[hildo@dep.ufscar.br](mailto:hildo@dep.ufscar.br)

Marcelo José Carrer

Universidade Federal de São Carlos

Rod. Washington Luiz, Km 235 – 13.565-905 - São Carlos, SP, Brazil

[marcelojcarrer@dep.ufscar.br](mailto:marcelojcarrer@dep.ufscar.br)

POMS 23rd Annual Conference

Chicago, Illinois, U.S.A.

April 20 to April 23, 2011

# **Adoption of technological and managerial requirements to export beef to the EU: a study of Brazilian farms**

**Abstract.** A sample of 83 cattle beef farms provided data to test hypotheses on economic and non-economic factors. A bivariate logit statistic model was used. It was found that high capital intensity, large scale, previous experience with certification, and farmers' experience, measured by age, play a positive role in the adoption.

**Key-words:** traceability; certification; technology adoption; cattle beef.

## **1. INTRODUCTION**

Since the 90's, consumers, particularly in Europe, have attributed great importance to quality and food safety. To a large extent, this concern is associated with the increase number of food contamination cases and the "mad cow" disease crisis (Bovine Spongiform Encephalopathy - BSE) and its association with Creutzfeldt-Jakob disease (CJD) in human.

These events highlighted close interdependence among different stages of the production chain and the limitations of quality control along the food chain (Hobbs, 2004), as well as fostered the adoption and diffusion of new legal rules and certification systems related to food safety and food quality. (Fulponi, 2006; Trienekens and Zuurbier, 2008). Technical and sanitary barriers were created by most import countries. Ensuring quality and food safety has become a fundamental condition to maintain or to have access to new international markets. Thus, traceability is at the core in the discussions on food chain management (Fritz and Schiefer, 2009).

Brazil had one of the largest commercial cattle herd in the world, free of BSE. The country is also the major exporter of beef, reaching 300 000 tons and, in 2007, around 2.4 million tons (Secex, 2010). Large share of the international market has

brought challenges to Brazilian beef industry. In particular, the European Union (EU) has increased food safety standards to import fresh beef. The European Union has demanded traceability and created a set of directives for their trade partners (Directives CE 820/97 and 178/2002) as conditions to have access to its market. The requirements are limited to the ability to track the history and origin of the product, do not include requirements related to the monitoring of product quality (Regattieri *et al.*, 2007).

The demands from the international market had impact on the national regulatory environment on food safety. In 2002, The Brazilian System of Identification and Certification of Bovine and Bubaline Origin (SISBOV) was created. This system, of voluntary adoption, is coordinated by the Ministry of Agriculture, Livestock and Food Supply, which is responsible for the approval and authorization of third part private certifiers. The SISBOV certification is necessary, but not sufficient condition to export to European Union. The farm must also be part of TRACES (Trade Control and Expert System). TRACES is a network created by European Union for veterinary health which notifies, certifies and monitors trade in animals and animal products. A SISBOV and TRACES certified farm must adopt traceability and a set of management and operational technologies.

The implementation of traceability leads to the adoption of practices such as individual identification of animals, records and documentation to track the history of animal movements, inventory control and the adoption of information technologies, such as software and electronic devices for cattle management (Nantes and Machado, 2005; Cocaro and Jesus, 2008). However, the level of diffusion of this certification is still low. A small number of farms have adopted it; consequently technological heterogeneity persists in bovine livestock production in Brazil. In 2010, there were only 1.895 certified farms in TRACES, of which 137 were located in the State of Sao Paulo,

Brazil (MAPA, 2010). The aim of this empirical research is to identify and analyze determinants of adoption both SISBOV and TRACES certification at the farm level in the State of São Paulo, Brazil.

## **2. THEORETICAL FRAMEWORK**

This section attempts to review the factors that are likely to influence the process of the adoption of the SISBOV/TRACES certification. The literature on technology adoption provides a framework to understand how farmers behave with regard to a new technology. According to Souza-Monteiro and Caswell (2009), most traceability systems are based on information technology. As the SISBOV certification requires the adoption of traceability at farm level, the empirical studies of adoption of information technologies are also used to identify variables that affect adoption. Based on the literature on agricultural technologies adoption, certification, traceability and information technologies adoption, two sets of factors have been highlighted: the farmers' characteristics and the farms' characteristics.

### **2.1. FARMERS' CHARACTERISTICS**

There is a wide literature which attributes to human capital variables important role in agricultural technical change (Rogers, 1983; Vicente, 2002; Conceição *et al.*, 2006). The role of human capital is analyzed by means of variables related to the level of education, experience, skills and abilities (Mizumoto, 2009).

Information plays an important role in the recognition of potentially valuable opportunities and the ability of individuals to exploit them economically. Better access to certain types of information and ability to use this information makes a person more able than others to recognize a good opportunity (Baron and Shane, 2007; Baron, 2007).

One indicator of this capacity is the level of education. Schultz (1975, cited by Hébert and Link, 1988) highlighted the effect of education on individuals' ability to perceive and respond to the opportunities arising from the market disequilibrium.

Empirical results in Vicente (2002) and Conceição *et al.* (2006) show the positive effect of educational level in the adoption and intensity of adoption of agricultural technologies in Brazil. Experiences from other countries confirm the positive impact of this variable in the adoption of agricultural technology (Rogers, 1983; Doye *et al.*, 2000; Abdulai and Huffman, 2005; Sidibé, 2005; Abdulai *et al.*, 2008; Ashraf *et al.*, 2009; King *et al.*, 2010; Kirk *et al.*, 2010) and traceability adoption (Souza-Monteiro and Caswell, 2009). The educational level of managers also positively influenced the adoption of ISO certification and Internet use (Correa *et al.*, 2010). The first hypothesis can be drawn from the above literature:

*H1: the higher the education levels of farmers greater the likelihood of adoption of SISBOV and TRACE certification.*

Experience is another way of getting knowledge. Previous experience and/or prior knowledge in areas related to new technology is one of the factors that influence farmer's behavior regarding the use of the new practice, which in turn affect the process of technology adoption. According to the literature on his area experience can affect self-efficacy, which refers to the belief that the person is able to perform a specific task, given a set of circumstances. Self-efficacy has an indirect effect on the adoption of technology. People with high self-efficacy, which is largely built up on past experience, have less anxiety regarding the use of the new practice. These individuals are more likely to adopt the new technology (Bandura, 1997; Czaja *et al.*, 2006).

The economic theory emphasized experience as a means for acquisition of entrepreneurial skills. Hébert and Link, 1988 showed that, in addition to formal education, knowledge is also obtained through daily experience; and different individuals get it in different degrees. The experience induces reflection, interpretations, and generalizations by individuals (Hébert and Link, 1988).

Farmers with large experience and tradition in agriculture, in general, have better performance than farmers with little or no experience in management of agricultural activity (Buainain, 1997). Vicente (2002) and Conceição *et al.* (2006) presented empirical results indicating the positive impact of experience in the rural activity on both the adoption and the intensity of adoption of agricultural technologies in Brazil.

The experience is a relevant factor to explain efficiency in management of traditional productive resources, but it is also important in the adoption of private standards and certification related to food safety and environmental management. Agricultural production for both export markets and niche markets is subject to these requirements. Souza-Monteiro and Caswell (2009) and Grolleau *et al.* (2007) found that previous experience with food safety systems, such as HACCP (Hazard Analysis and Critical Control Points), GAP (Good Agricultural Practices), among others, facilitates the adoption of traceability and certification on environmental sustainability. The total cost reduction, mainly the cost of learning, explains this positive correlation. Canavari *et al.* (2010)'s case study on traceability in fruit chain showed that the diffusion of the ISO standards enabled the adoption of tracking systems.

*H2: farmers with previous experience in quality management practices or other certifications are more likely to adopt the SISBOV and TRACES certification.*

In addition to formal education and experience, sharing information on a wide social network help to increase the knowledge base and access to key information (Baron and Shane, 2007; Baron, 2007; Hartog *et al.*, 2009). The central idea of social capital is that social networks and the concept of reciprocity have a value (Putnam, 2001).

Social capital takes many forms. Some of them are formal, like farmers associations. Other forms can be informal, like groups of people who meet regularly for sports activities. Both are social networks where reciprocity is developed and allows gains (Putnam, 2001).

Farmer participation in formal associations, organizations and cooperatives has been considered as proxy variable for social capital in empirical studies on technology adoption (Souza Filho, 2001; Silva and Teixeira, 2002; Sidibé, 2005; Monte and Teixeira, 2006; Wubeneh and Sanders, 2006). Souza-Monteiro and Caswell (2009) founded positive relationship between the affiliation to farmers' organization and the adoption of traceability systems in pear production in Portugal.

*H3: farmers affiliated to cattle beef farmers' organization are more likely to adopt SISBOV and TRACES certification.*

Farmers' ability to organize and understand information can speed up adoption. Fluid intelligence is responsible for speed up information processing. This type of intelligence has negative relation with age. Young people tend to process information faster than old one. On the other hand, age has a positive relation to the knowledge, which is obtained during the life. This kind of knowledge is known as the crystallized intelligence (Beier and Ackerman, 2005).

According to Souza-Monteiro and Caswell (2009) adoption of traceability frequently requires the adoption of information technologies. Empirical research related to the adoption of information technologies found an inverse relationship between age and adoption (Huffman e Mercier, 1991; Czaja *et al.*, 2006; Charness and Boot, 2009). Empirical studies related to the adoption of agricultural technologies identified the adverse effects that age can have on the adoption of new practice. On the one hand, more experience - measured by either age or years of work in agriculture - is a positive factor in the adoption of sustainable practices, because it may indicate a greater ability for agricultural management. On the other hand, older farmers may have less energy and/or have a shorter planning horizon (Rahm and Huffman, 1984; Anosike and Coughenour, 1990; D'Souza, *et al.*, 1993). Buainain *et al.* (2002) propose that younger farmers tend to be more easily attracted to novelty and more likely to be early adopters of new agricultural practices. Souza-Monteiro and Caswell (2009) found that younger farmers were more likely to adopt more complex systems of traceability.

*H4: Younger farmers are more likely to adopt SISBOV and TRACES certification.*

## **2.2. FARMS' CHARACTERISTICS**

Although enough information is available, the decision to adopt new technology can be influenced by economic barriers. In the case of agriculture, farm size is critical. This variable may be relevant as long as large farms may allow greater flexibility in production decisions, greater access to discretionary resources and better information, more opportunities to test new practices and higher ability to deal with risk and uncertainty (Souza Filho, 2001). Besides the advantages mentioned, larger farms can also benefit from economies of scale (Galliano and Orozco, 2011).

The traceability implementation has high set up cost and some agents may not get the economic benefits of adoption (Kher *et al.*, 2010). Some empirical studies have found a positive relationship between size of the farm and adoption of traceability (Souza-Monteiro and Caswell, 2009; Galliano and Orozco, 2011). The probability of adoption of ISO certification was also positively influenced by the firm size (Correa *et al.*, 2010). The adoption of information technology by farms, particularly e-marketing, is also positively correlated with the farm size (Baer and Brown, 2007).

*Hypothesis 5: Number of cattle heads, used as a proxy for size, is positively related to the adoption of SISBOV and TRACES certification.*

Increase use of inputs can increase profit, but also can increase risk and complexity of the production system. The cost structure changes and requires further expenditure. This scenario also requires rigorous management of production (Correa *et al.*, 2000). High capital intensive production system is also managerial intensive. Precise controls of inventory and production costs are central to the success of more intensive production systems. In very intensive beef cattle raising systems, animal price plays an important role in profitability (Arieira *et al.*, 2007). SISBOV and TRACES certification may allow premium prices, which reduces the risk of intensive systems.

The adoption of SISBOV and TRACES certification requires rigorous controls of documentation and inventory. It also requires precise controls of inventory and documentation of animals' movements. Farmers who adopt capital intensive production system, like feedlot, are more likely to adopt traceability.

Huffman and Mercier (1991) studied the adoption of computers by farmers. The empirical results show a positive relationship between the increase in the complexity of rural activity and the likelihood of technology adoption. The complexity of rural activity

was defined on a scale of zero (low complexity) to five (high complexity). A large cattle farm was classified as level four of complexity.

*H6: cattle raisers who fatten animals in intensive production systems are more likely to adopt the SISBOV and TRACES certification.*

Box 1 shows the variables and the expected results for each based on the theoretical framework and empirical evidences presented above.

**Box 1.** Expected results for the variables determining SISBOV/TRACES certification adoption by farmers in the State of São Paulo, Brazil.

Variable	Empirical studies that used the variable	Expected sign
Education	Conceição <i>et al.</i> (2006); Vicente (2002); Souza-Monteiro and Caswell (2009); King <i>et al.</i> (2010); Kirk <i>et al.</i> (2010); Ashraf <i>et al.</i> (2009); Abdulai <i>et al.</i> (2008); Abdulai and Huffman (2005); Sidibé (2005); Doye <i>et al.</i> (2000)	(+)
Previous experience	Conceição <i>et al.</i> (2006); Vicente (2002); Souza-Monteiro and Caswell (2009); Grolleau <i>et al.</i> (2007)	(+)
Participation in farmers organizations	Monte and Teixeira (2006); Sidibé (2005); Silva and Teixeira (2002); Souza Filho (2001); Souza-Monteiro and Caswell (2009)	(+)
Age	Czaja <i>et al.</i> (2006); Charness and Boot (2009); Huffman e Mercier (1991); Souza-Monteiro and Caswell (2009)	(-)
Size	Galliano and Orozco (2011); Souza-Monteiro and Caswell (2009); Baer and Brown (2007); Correa <i>et al.</i> (2010); Montiel and Husted (2009)	(+)
Capital intensive production systems	Huffman and Mercier (1991)*	(+)

\*Complexity of rural activity.

### 3. METHODOLOGY

#### 3.1. THE SAMPLE

A survey questionnaire was used to get information on: characteristics of the farm (e.g. size and production system) and characteristics of the farmer. The latter was

divided in human capital (e.g. age, experience and education) and social capital (e.g. participation on farmer organization). The sample comprises cross section data on 31 certified farmers, which were randomly selected from a population of 137 certified and approved farms on TRACES (Trade Control and Expert System) list of the State of São Paulo, Brazil, and 55 non-certified counterfactual farms. The definitions of the variables used in the quantitative analysis are presented in Table 1; Table 2 provides some descriptive statistics of the sample farms and farmers.

**Table 1. Definition of farmer and farm characteristics.**

Education	Years of formal education of the farmer
Experience	Adoption of previous certification or quality practices = 1, = 0 otherwise
Assoc	Participation on producer organization = 1, = 0 otherwise
Age	Age of the farmer at the date of the survey (years)
Size	Number of cattle
Feedlot	Adoption of capital intensive livestock production system = 1, = 0 otherwise

**Table 2. Descriptive statistics of sample farmers and farms.**

	Certified farms (31)		Non-certified farms (52)	
	mean	s.d.	mean	s.d.
Education	16,387	1,726	15,000	2,910
Assoc	0,355	0,486	0,192	0,398
Age	52,839	11,816	50,654	12,128
Size	9.419,484	13.265,757	959,923	1.390,857
Feedlot	0,806	0,402	0,346	0,480
Expererience	0,774	0,425	0,288	0,457

### 3.2. LOGIT MODEL

The empirical analysis of the survey data is performed with the estimation of a logit model. The discrete choice models has been also performed by other empirical analyses on the adoption of traceability system as well as information technologies (Souza-Monteiro and Caswell, 2009; Galliano and Orozco, 2011; Correa *et al.*, 2010). The variable to be "explained" is the dichotomous choice: adoption/non-adoption.

In making the decision on whether or not to adopt the traceability system and the certification, it may be assumed that the farmer weighs up the marginal advantages and disadvantages of the technology. As the parameters of this decision are not usually observable, for each farmer  $i$  we can define a latent variable,  $y_i^*$ , as

$$y_i^* = \beta' X_i + u_i \quad i = 1, \dots, N \quad (1)$$

where  $X$  denotes a set of explanatory variables. The observed pattern of demand can be described by a dummy variable,  $y$ , such that  $y_i=1$  if farmer  $i$  has adopted,  $y_i=0$  if he/she has not adopted. These observed values of  $y$  are related to  $y^*$  as follows:

$$y_i = 1 \text{ if } y_i^* > 0 \quad (2)$$

$$y_i = 0 \text{ otherwise}$$

and

$$\begin{aligned} Pr(y_i = 1) &= Pr(y_i^* > 0) = Pr(u_i > -\beta' X_i) = 1 - F(-\beta' X_i) \\ &= F(\beta' X_i) \end{aligned} \quad (3)$$

where  $F$  is the cumulative distribution function for  $u$  and a symmetric distribution is assumed. Using maximum likelihood procedures, estimates of the  $\beta$  parameters can be obtained.

For the logit model, a logistic cumulative distribution function is assumed,

$$\begin{aligned}\Pr(y_i = 1) &= \frac{e^{\beta X}}{1 + e^{\beta X}} \\ &= \Lambda(\beta' X)\end{aligned}\tag{4}$$

where  $\Lambda$  denotes the logistic cumulative distribution function.

Here, the ‘odds ratios’ (or  $e^{\beta}$ ) rather than the  $\beta$  coefficients themselves are presented. The interpretation is that as the explanatory variables change, the probability of farmers adopts the traceability and certification changes by that factor. In other words, variables with an odds ratio greater than unity would increase the probability of demand, while those with a value of less than unity would have a negative impact on the certification adoption.

#### **4. RESULTS<sup>1</sup>**

Table 3 provides the results of the logit model. The likelihood ratio (LR) was used to test the hypothesis that all the slope coefficients in the logit model are zero. The restricted log likelihood value is -54,8454. The unrestricted log likelihood value is -30,4999. The LR test statistics are therefore 48,69. With 6 degrees of freedom, the critical value at the 5% significance level is 18,55, and so the joint hypothesis that the coefficients on the full set of variables are all zero is rejected.

---

<sup>1</sup> All empirical analysis has been undertaken using Statistica 10.0.

**Table 3. Specification of the Logit Model.**

Number of obs = 83		Log-likelihood = -30,4999		
Chi <sup>2</sup> (6) = 48,69		Nagelkerke R <sup>2</sup> = 0,6052		
Variables	Odds Ratio	Std. Error.	Wald Stat.	p
Feedlot*	2,4797	0,3748	5,8696	0,015
Experience**	1,8762	0,3480	3,2696	0,071
Assoc	1,0164	0,3751	0,0019	0,965
Age*	1,0865	0,0347	5,7153	0,017
Education	1,1167	0,1320	0,6987	0,403
Size*	1,0004	0,0002	4,2058	0,040

Observed	Prediction		Total	Percent correct
	0	1		
0	23	8	31	<b>74,19</b>
1	6	46	52	<b>88,46</b>
Total	31	52	83	

\* Significant at 5% level

\*\* Significant at 10% level

The interpretation of odds ratios ( $e^{\beta}$ ) can be made using the formula  $[(e^{\beta}-1)*100]$ , which shows the change in percentage points in the probability of the dependent variable to be equal to 1 (adoption of SISBOV certification) as a response to the change of one unit in the independent variable.

The results of the estimated parameters of the model for the adoption of capital intensive livestock production system, farm's size, previous experience with other certification or quality practices, participation in formal farmers organization and level of schooling of the farmer are in agreement with the theory. These parameters had the expected sign and, with the exception of Schooling and Association, all other variables are statistically significant levels of 5% or 10% significance. Thus, we can accept the

hypotheses 2, 5 and 6 established in section 2. The parameter for Age presented different sign than expected and is statistically significant at 5% level.

The variable Age is controversy among the technology adoption empirical findings. The literature review performed by Rogers and Shoemaker (1971, cited by Rogers, 1983) didn't find a consensus for this variable. Also, Rahm and Huffman, 1984, Anosike and Coughenour, 1990 and D'Souza, *et al.*, 1993 mentioned the contradictory effects of age on technologies adoption.

In the psychology cognitive literature, the age is one of the indicators used to analyze intelligence. The relationship between age and technology adoption is mediated by fluid and crystallized intelligence. Although both intelligences are correlated, they have different relationships with age (Beier and Ackerman, 2005). On the one hand, an increase in age reduces fluid intelligence, and therefore, the likelihood of technology adoption. On the other hand, the same increase in age maintains or increases the crystallized intelligence, and therefore, the likelihood of adoption. Thus, an increase in age could lead to either an increase or reduction of adoption likelihood. If the net effect establishes a positive relationship between age and technology adoption, the crystallized intelligence is predominant. In this case, it is inferred that the technology is more demanding on knowledge acquired throughout life, i.e., management experience.

The variable Feedlot has the greatest impact on the probability of farmers to adopt the SISBOV/TRACES certification. The odds of adopting the SISBOV/TRACES certification significantly increases when farmers raise cattle at a feedlot system. In fact, this system is not only a high capital intensive production system but is also managerial intensive. The set of practices and controls already performed in the feedlot management comprises most of the necessary managerial procedures and facilities for the adoption of SISBOV/TRACES certification.

The results suggest that the previous compliance with other certification or quality assurance program, such as GlobalGap or Good Agricultural Practices, can increase the probability of SISBOV/TRACES certification adoption. Some initiatives of cattle quality programs coordinated by either slaughterhouses or farmers organizations increase farmer' experience in documentation procedures and audits. The outcome variable for Experience in this study confirms other empirical findings (Souza-Monteiro and Caswell, 2009).

The odds ratio of Size shows that adoption of SISBOV/TRACES certification significantly increases when the farm has large herds. This result also confirms other empirical studies (Souza-Monteiro and Caswell, 2009; Galliano and Orozco, 2011). This variable is associated to economies of scale associated with fixed costs of certification (Galliano and Orozco, 2011).

## **5. CONCLUSIONS**

Farm SISBOV/TRACES certification is required to export beef to European Union. This certification implies the adoption of traceability and a set of management and operational technologies. Several studies have shown the costs and benefits of traceability adoption. However relatively few studies have looked at factors that affect their adoption at the farm level. This paper presents an empirical analysis of the adoption of a certification required to export to European Union in the Brazilian Beef chain.

The analysis suggests that a higher probability of SISBOV certification adoption is associated with larger herds and high capital intensive production system. Older farmers and the previous compliance with other certification or adoption of quality practices also increase the probability of SISBOV certification adoption.

In terms of policy implications, this article provides indications regarding the types of farmers that could face difficulties in the adoption the SISBOV certification. These are small farms, which raise herds in less extensive production system. Also, the implementation of traceability requires taught experience (learning by doing) regarding documentation procedures and audits. Additionally, previous experience with quality control practices or certification play an important role. These results can be useful for policies providing incentives to diffuse innovation in agriculture.

#### **ACKNOWLEDGMENT**

The research was supported by the Foundation for Research Support of the State of São Paulo, Brazil (FAPESP). The analysis and comments are however the authors' responsibility.

#### **REFERENCES**

ABDULAI, A.; MONNIN, P.; GERBER, J. Joint estimation of information acquisition and adoption of new Technologies under uncertainty. *Journal of International Development*, 20, p. 437-451, 2008.

ABDULAI, A.; HUFFMAN, W.E. The diffusion of new agricultural technologies: the case of crossbred-cow technology in Tanzania. *American Journal of Agricultural Economics*, 87, 3, p. 645-659, 2005.

ANOSIKE, N., COUGHENOUR, C. M. The socioeconomic basis of farm enterprise diversification decisions, *Rural Sociology* 55, 1, p. 1-24, 1990.

ARIEIRA, J.O.; DIAS-ARIEIRA, C.R.; GOZER, I.C. Análise comparativa de sistemas de produção de gado de corte: pasto rotacionado x confinamento. *In: Congresso brasileiro de economia rural, 45, 2007, Londrina. Anais...* Londrina: SOBER: UEL, 2007. 1 CD-ROM.

ASHRAF, N; GINÉ, X.; KARLAN, D. Finding missing markets (and a disturbing epilogue): evidence from an export crop adoption and marketing intervention in Kenya. *American Journal of Agricultural Economics, 91, 4, p. 973-990, 2009.*

BAER, A.G.; BROWN, C. adoption of e-marketing by direct-market farms in the northeastern United States. *Journal of Food Distribution Research, 38, 2, 2007.*

BANDURA, A. *Self-efficacy: The exercise of control.* New York: W. H. Freeman, 1997.

BARON, R.A. Behavioral and cognitive factors in entrepreneurship: entrepreneurs as the active element in new venture creation. *Strategic Entrepreneurship Journal, 1, p.167-182, 2007.*

BARON, R.A.; SHANE, S.A. *Empreendedorismo: uma visão do processo.* São Paulo: Thomson Learning, 2007.

BEIER, M.E.; ACKERMAN, P.L. Age, ability and the role of the prior knowledge on the acquisition of new domain knowledge: promising results in a real-world learning environment. *Psychology and Aging, 20, 2, p.341-355, 2005.*

BUAINAIN, A.M. *Recomendações para a formulação de uma política de fortalecimento da agricultura familiar no Brasil*. Campinas: Convênio FAO/INCRA, 1997. (Mimeogr.).

BUAINAIN, A.M.; SOUZA FILHO, H.M. SILVEIRA, J.M. Agricultura familiar e condicionantes da adoção de tecnologias agrícolas. *In: Inovação nas tradições da agricultura familiar*. Brasília: CNPq/Paralelo 15, 2002. 400p.

CANAVARI, M; CENTONZE, R.; HINGLEY, M.; SPADONI, R. Traceability as part of competitive strategy in the fruit supply chain. *British Food Journal*, 112, 2, p. 171-186, 2010.

COCARO, H.; JESUS, J.C.S. Casos sobre a rastreabilidade bovina em empresas rurais informatizadas: impactos gerenciais. *In: Congresso brasileiro de economia rural*, 46, 2008, Rio Branco. Anais... Rio Branco: SOBER: UFA, 2008. 1 CD-ROM.

CONCEIÇÃO, J.C.P.R.; ARAÚJO, P.F.C.; CONCEIÇÃO, P.H.Z. Influência de variáveis representativas de capital humano na adoção de inovações tecnológicas na agricultura brasileira. *In: VII Congresso Latino-americano de Sociologia Rural*. Anais... Equador, nov. 2006.

CORREA, E.S.; VIEIRA, A.; COSTA, F.P.; CEZAR, I.M. Sistema semi-intensivo de produção de carne de bovinos nelores no centro-oeste do Brasil. *Documentos*, Campo Grande: Embrapa Gado de Corte, 2000. 49 p.

CORREA, P.G.; FERNANDES, A.M.; UREGIAN, C.J. Technology adoption and the investment climate: firm-level evidence for Eastern Europe and Central Asia. *The World Bank Economic Review*, 24, 1, p. 121-147, 2010.

CHARNESS, N.; BOOT, W.R. Aging and information technology use potential and barriers. *Current Directions in Psychological Science*, 18, 5, p.253-258, 2009.

CZAJA, S.J.; FISK, A.D.; HERTZOG, C.; ROGERS, W.A.; CHARNESS, N.; NAIR, S.N.; SHARIT, J. Factors predicting the use of technology: findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychology and aging*, 21, 2, p.333-352, 2006.

DOYE, D; JOLLY, R.; HORNBAKER, R.; CROSS, T.; KING, R.P.; LAZARUS, W.F.; YEBOAH, A. Case studies of farmers' use of information systems. *Review of Agricultural Economics*, 22, 2, p. 566–585, 2000.

D'SOUZA, G.; CYPHERS, D.T. PHIPPS Factors affecting the adoption of sustainable agricultural practices, *Agricultural and Resource Economics Review* 22, 2, p.159-165, 1993.

FRITZ, M.; SCHIEFER, G. Tracking, tracing, and business process interests in food commodities: A multi-level decision complexity. *Int. J. Production Economics*, 117, p. 317–329, 2009.

FULPONI, L. Private voluntary standards in the food system: The perspective of major food retailers in OECD countries. *Food Policy*, 31, 1, p. 1-13, 2006.

GALLIANO, D.; OROZCO, L. The determinants of electronic traceability adoption: a firm-Level analysis of French agribusiness. *Agribusiness*, 27, 3, p.379-397, 2011.

GROLLEAU, G.; MZOUGHI, N.; THOMAS, A. What drives agrifood firms to register for an environment management system? *European Review of Agricultural Economics*, 34, 2, p. 233–255, 2007.

HARTOG, J.; PRAAG, M.V.; SLUIS, J.V.D. If you are so smart, why aren't you an entrepreneur? Returns to cognitive and social ability: entrepreneurs versus employees. *Journal of Economics and Management Strategy*, October, 2009.

HÉBERT, R. F.; LINK. A.N. *The Entrepreneur: Mainstream Views and Radical Critique*. Second edition, New York: Praeger. 1988.

HOBBS, J.E. Information asymmetry and the role of traceability systems. *Agribusiness*, 20, 4, p. 397–415, 2004.

HUFFMAN, W.E., MERCIER, S. Joint adoption of microcomputer technologies: an analysis of farmers decisions. *Review of Economics and Statistics*, 73, p. 541–546, 1991.

KHER, S.V; FREWER, L.J.; DE JONGE, J.; WENTHOLD, M.; DAVIES, O.H.; LUIJCKX, N.B.L; CNOSSEN, H.J. Experts' perspectives on the implementation of traceability in Europe. *British Food Journal*, 112, 3, p. 261-274, 2010.

KING, E., MONTENEGRO, C. E.; ORAZEM, P. F. F. Economic Freedom, Human Rights, and the Returns to Human Capital: An Evaluation of the Schultz Hypothesis

(August 1, 2010). World Bank Policy Research Working Paper Series, 2010. Available at SSRN: <http://ssrn.com/abstract=1669105>

KIRK, C.C.A.; WINTERS, P.C.; DAVIS, B. Globalization and Smallholders: The Adoption, Diffusion, and Welfare Impact of Non-traditional Export Crops in Guatemala. *World Development*, 2010.

MINISTÉRIO DA AGRICULTURA, PECUÁRIA E ABASTECIMENTO – MAPA, 2010. SISBOV (Serviço Brasileiro de Rastreabilidade da Cadeia Produtiva de Bovinos e Bubalinos). Available in: <[www.agricultura.gov.br](http://www.agricultura.gov.br)>. Access: 02 August, 2010.

MIZUMOTO, F.M. Strategy and entrepreneurial action in family business: the analysis of human capital and social capital. *Tese (PhD)*. São Paulo: FEA, 2009. 140 p.

MONTE, E.Z.; TEIXEIRA, E.C. Determinantes da adoção da tecnologia de despulpamento na cafeicultura. *Revista de Economia Rural*, 44, 2, p.201-217, 2006.

NANTES, J.F.D.; MACHADO, J.G.C.F. Segurança dos alimentos e rastreabilidade: o caso da carne bovina no Brasil. In: BATALHA, M.O. *Gestão do agronegócio: textos selecionados*. São Carlos: EdUFSCar, 2005. Cap. 8, p. 369-423.

PUTNAM, R. Social Capital: Measurement and Consequences. *Isuna Canadian Journal of Policy Research*, 2, 1, p. 41–51, 2001.

RAHM, M.R., HUFFMAN, W.E. The adoption of reduced tillage: The role of human capital and other variables, *American Journal of Agriculture Economics*, 66, p. 405-413, 1984.

REGATTIERI, A.; GAMBERI, M.; MANZINI, R. Traceability of food products: general framework and experimental evidence. *Journal of Food Engineering*, 81, p. 347–356, 2007.

ROGERS, E.M. *Diffusion of innovations*. New York: The Free Press. 3<sup>rd</sup> ed. 1983. 453 p.

SECRETARIA DE COMÉRCIO EXTERIOR - Secex, 2010. Available in: <http://www.mdic.gov.br/sitio/interna/interna.php?area=5&menu=1955&refr=608> Access: December, 2010.

SIDIBÉ, A. Farm-level adoption of soil and water conservation techniques in northern Burkina Faso. *Agricultural Water Management*, 71, p. 211-224, 2005.

SILVA, S.P.; TEIXEIRA, E.C. Determinantes da adoção da tecnologia “plantio direto” na cultura da soja em Goiás. *Revista de Economia e Sociologia Rural*, 40, 2, p.305-326, 2002.

SOUZA FILHO, H.M. Desenvolvimento agrícola sustentável. In: *Gestão agroindustrial*, São Paulo: Atlas, 2001. 690 p.

SOUZA FILHO, H.M.; ROSA, F.T.; VINHOLIS, M.M.B. Análise da competitividade da cadeia produtiva da carne bovina do Estado de São Paulo. *Informações Econômicas*, SP, 40, 3, mar. 2010.

SOUZA-MONTEIRO, D. M.; CASWELL, J.A. Traceability Adoption at the Farm Level: An Empirical Analysis of the Portuguese Pear Industry. *Food Policy* 34, 1, p.94-101, 2009.

TRIENEKENS, J.; ZUURBIER, P. Quality and safety standards in the food industry, developments and challenges. *Int. J. Production Economics*, 113, p. 107–122, 2008.

VICENTE, J.R. *Pesquisa, adoção de tecnologia e eficiência na produção agrícola*. São Paulo: Apta/Série Discussão, 2002, 153 p.

WUBENEH, N.G.; SANDERS, J.H. Farm-level adoption of sorghum technologies in Tigray, Ethiopia. *Agricultural Systems*, 91, p. 122-134. 2006.