

Factors associated with the technology adoption in dairy agribusiness

Factores asociados con la adopción tecnológica en agronegocios lecheros

doi: 10.15446/rfnam.v73n2.82169

Dursun Barrios^{1,2*}, Fernando José Restrepo-Escobar³ and Mario Cerón-Muñoz⁴

ABSTRACT

Keywords:

Agricultural development
Productivity
Rural economics
Structural equations

The adoption of adequate technologies is essential to improve the performance of different kinds of companies. Although there is literature related to the adoption of technology in dairy agribusiness in developed countries, information about it is scarce in developing countries. The objective of this study was to explore the factors associated with the adoption of technology by dairy agribusiness. A structural analysis was conducted to evaluate the relationships between the internal variables of Antioquia province farms, Colombia, and their technology adoption process. This process was explained by two factors: production-related variables and management-dependent traits. The variables resulting in the greatest impact were pasture improvement, genetics, administration, and technical procedures.

RESUMEN

Palabras clave:

Desarrollo agrario
Productividad
Economía agraria
Ecuaciones estructurales

La adopción de tecnologías adecuadas es esencial para incrementar el desempeño de las compañías. Aunque existe literatura relacionada con la adopción tecnológica en agronegocios lecheros en países industrializados, la información acerca de este fenómeno en países en vía desarrollo es escasa. El objetivo fue explorar los factores asociados a la adopción tecnológica en agronegocios lecheros. Se realizó un análisis estructural para evaluar la relación entre variables internas en granjas del departamento de Antioquia, Colombia y el proceso de adopción de tecnologías. La adopción tecnológica fue explicada mediante dos constructos: producción y gestión, siendo el mejorar los pastos, la genética, la gestión administrativa y los procedimientos técnicos las variables de mayor impacto.

¹ Facultad de Ciencias Agrarias, Universidad Nacional de Colombia. AA. 14490. Bogotá, Colombia.

² PhD student. Facultad de Ciencias Agrarias, Universidad de Antioquia. AA. 1226, Medellín, Colombia.

³ Escuela de Economía, Administración y Negocios. Universidad Pontificia Bolivariana. Circular 1 No. 70-01. Medellín, Colombia.

⁴ Facultad de Ciencias Agrarias, Universidad de Antioquia. AA. 1226, Medellín, Colombia.

* Corresponding author: <dbarrio@unal.edu.co>

Technology appropriation helps reducing workload, improves the life quality of farmers, and increases farm performance (Tse *et al.*, 2018). Although the use of technology has increased in recent years, its adoption rate by the dairy sector has been slow compared with other industries (Russell and Bewley, 2013).

Investing in dairy farming technologies implies overcoming several challenges. It is necessary to consider the reasons argued for investing or not (Steenefeld and Hogeveen, 2015), the technical efficiency (Steenefeld *et al.*, 2012), and its economic consequences (Bijl *et al.*, 2007), among others. Lack of analysis of the specific conditions and needs of farmers is a relevant factor that discourages investment (Luvisi, 2016).

Information about the adoption and use of technology by dairy farmers in developing countries is scarce (Janssen and Swinnen, 2017). This includes Colombia, where such lack of information could be related to its low rate of technology adoption (Barrios *et al.*, 2019). Therefore, it is necessary to investigate the technology adoption processes by dairy farmers in this country. The results could improve decision making and productive performance in a sector that is still immature regarding organizational issues and business management (Vásquez-Jaramillo *et al.*, 2018). The objective of this study was to establish the factors associated with the adoption of technologies by dairy agribusiness. The findings could help increase the effectiveness of research and policy-making agencies for supporting extension programs.

MATERIALS AND METHODS

A survey that included 45 questions distributed in two sections was carried out to determine the factors related to technology adoption. The first section provided the information required for a general understanding of demographics and productive characteristics of dairy agribusiness. The second section focused on those factors that farmers considered important to make decisions on whether or not to adopt a technology. Data were collected between May and December 2018.

A total of 280 farmers across eight municipalities of Antioquia province, Colombia, responded to the survey. Stratified sampling by size (Sorge *et al.*, 2016) and municipality (Milán *et al.*, 2003) was used. The municipalities were: Bello (14), Belmira (25), Donmatías (25), Entrerriós (29), San José de la Montaña (7), San Pedro de los Milagros (61), Santa Rosa de Osos (76), and Yarumal (43).

A Likert response scale with levels from 1 ("Not important") to 5 ("Very important") was used to evaluate the relationship between the process of technology adoption and the farm operational and management variables. The statistical procedure included an exploratory factor analysis using the psych library (Revelle, 2017) of the R-project software (R Core Team, 2018) and a model of structural equations. According to the Schmid-Leiman procedure (Revelle, 2017), only variables with Cronbach's alpha values higher than 0.70 and a factorial load higher than 0.25 were included in the model. Model fit was validated by a Root Mean Square Error of Approximation (RMSEA) less than 0.1 and both Comparative Fit Index (CFI) and Goodness of Fit Index (GFI) greater than 0.9 (Cangur and Ercan, 2015) using the lavaan library (Rosseel, 2012) of the R-project software (R Core Team, 2018).

RESULTS AND DISCUSSION

The average age of farmers was 47 ± 12 years, and they had 25 ± 13 years of experience in dairy farming (Table 1). Both traits are known to favor productivity, considering that experiential knowledge facilitates decision-making (Cuartas-Martínez *et al.*, 2018). However, this knowledge was not accompanied by academic training; on average, they attended through eighth grade, which means they did not complete high school. This finding is known to discourage "Management by Competencies" and limits individual and organizational learning (Pardo and Díaz, 2014). This could explain why the Colombian dairy sector has been focused for years on its survival rather than growth and business development (Barrios *et al.*, 2016).

Table 1. Relevant characteristics of dairy agribusiness in Antioquia, Colombia.

Item	Mean \pm SD	Median
Age of farmers (yrs)	47 \pm 12	48
Experience of farmers in the dairy business (yrs)	25 \pm 13	25
Number of full-time employees	1.99 \pm 1.83	1
Distance from the main town (km)	10.61 \pm 6.82	10

Regarding organizational characteristics, 70% of producers work in their own farms (Table 2). This factor, added to the fact that in 62.85% of cases there was a successor to the business, could promote the adoption of new technologies by this type of organization since there is certainty about the fate of the property in the long term. It could be related to the fact that 74.64% of farmers have used medium or long-term financing, a figure higher than that found by Rodríguez

et al. (2015), who reported, for the same region, a 38% credit-access rate. In that study, they also reported that the technical assistance rate was 50%, meaning that coverage of technical assistance and technology transfer programs have improved in recent years, reaching 89.64% for the surveyed organizations. These results are positive because such programs help to guide farmers towards appropriate decision-making processes (Cerón-Muñoz *et al.*, 2015).

Table 2. Organizational characteristics of dairy agribusiness in Antioquia, Colombia.

Item	%
There is a successor to the business	62.85
The farmer is the owner of the farm	70.00
The farmer has used medium or long-term financing	74.64
The farmer is associated with a cooperative	53.57
The farmer regularly attends technology-related fairs and other events	90.36
The farmer has received technical assistance from the government	89.64

Improvement of milk quality, Pastures, and Herd genetics were the most important aspects that influence a farmer's intention to adopt technologies, averaging 4.58 ± 0.59 , 4.57 ± 0.61 , and 4.52 ± 0.63 , respectively (Table 3). A tendency to favor the adoption of technologies related to purely technical aspects is frequent in the dairy sector, where it is common to find higher adoption rates of "hard" technologies in comparison to those associated with knowledge management and improvement of

procedures and management methods (Barrios *et al.*, 2016).

Human management was the least relevant variable when deciding on the adoption of technologies (3.09 ± 1.41). This result disagrees with the report by Steeneveld and Hogeveen (2015), who found that investment in dairy technology significantly reduces labor, decreases production costs, and improves the life quality of farmers.

Table 3. Factors that influence technology adoption by dairy agribusiness in Antioquia, Colombia¹

To improve	%			Mean±SD
	Not important	Important	Very important	
Milk quality	0.4	8.2	91.4	4.58±0.59
Pasture quality	1.1	7.8	91.1	4.57±0.61
Herd genetics	0.4	8.9	90.7	4.52±0.63
Production cost	2.5	17.5	80.0	4.39±0.85
Administrative procedures	5.7	15.7	78.6	3.93±0.90
Supplies	3.9	24.3	71.8	4.02±0.93
Equipments	6.1	32.8	61.1	3.85±1.06
Technical procedures	6.8	33.9	59.3	3.76±0.98
Recognition of the farm in the market	18.2	26.8	55.0	3.54±1.28
Human management	24.4	36.2	39.4	3.09±1.41

¹Response categories: 1 = Not important, 3 = Important, and 5 = Very important.

Variables with no statistical significance were eliminated after the exploratory analysis. Thus, only ten variables grouped into two factors were included in the structural equation model. This helped to identify the structure of the relationships between variables and

conformed factors (Table 4). According to the common characteristics of variables grouped in each factor, it was possible to name Factor 1 as a production-related factor, while Factor 2 included variables related to business management.

Table 4. Variables associated with technology adoption by dairy agribusiness in Antioquia, Colombia

Factor	Variable	Factor loading	Mean±SD	Cronbach's alpha
Production	Pasture quality	0.70	4.57±0.61	0.70
	Herd genetics	0.65	4.52±0.63	
	Production costs	0.59	4.39±0.85	
	Equipment	0.53	3.85±1.06	
	Milk quality	0.51	4.58±0.59	
Management	Administrative management	0.69	3.93±0.89	0.71
	Technical procedures	0.66	3.76±0.98	
	Human resource management	0.58	3.09±1.41	
	Supplies	0.57	4.02±0.93	
	Farm recognition in the market	0.43	3.54±1.28	

The structural equation model resulted in a Cronbach's alpha value higher than 0.7 for the proposed factors (Table 4), with 0.072 RMSEA, and fit indexes of 0.921 and 0.948 for the CFI and the GFI, respectively. This indicates the internal consistency of the scale and a good fit of the model (Cupani, 2012).

Factor "Production" included the following variables: *Pasture, Herd genetics, Production costs, Equipment, and Milk quality* (Figure 1). *Pastures* and *Herd genetics* were the most representative variables, with 0.7- and 0.65-factor loads, respectively. This could be due to the

fact that forage quality and genetic improvement are related to dairy herd planning (Múnera-Bedoya *et al.*, 2018; Cerón-Muñoz *et al.*, 2017) which is considered a strategic tool linked to technology adoption. It is important to mention that variable *Production costs* (with 0.59 factorial load) was one of the aspects that determined the adoption of technology, which could promote the analysis of costs in this sector, considering that this industry has presented historically low rates of economy diagnostic at the organizational and sectorial level (Barrios and Olivera, 2013).

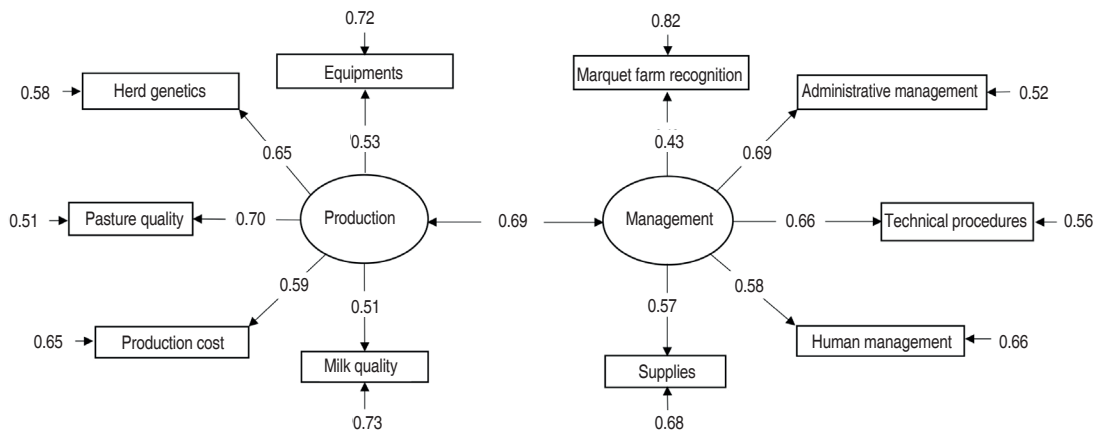


Figure 1. Structural equation model for factors associated with technology adoption by dairy agribusiness in Antioquia, Colombia.

The second factor, "Management," was impacted by variables: *Administrative management*, *Technical procedures*, *Human resource management*, *Supplies*, and *Farm recognition in the market*. The variables with the greatest weight in the factor were *Administrative management* (0.69 factorial load) and *Technical procedures* (0.66 factorial load). These variables are related to document management, which denotes the importance of information traceability for adequate analysis and subsequent decision making (Londoño *et al.*, 2016).

Although variable *Farm recognition in the market* had the lowest factor load (0.43), it is important to highlight how the decision to adopt technology is positively influenced by the image that the farm could project in the sector. This result is somewhat unusual, considering that this market has a regional oligopsonic structure where, in normal conditions, the total production of milk is sold (Von Keyserlingk *et al.*, 2013). This could be associated with having a productive system with technology levels in line with or higher than the industry standard, which in the long term can be considered as a sustainability strategy for the organization (Adefulu, 2015).

CONCLUSIONS

The intention to adopt technologies by dairy farmers is influenced by factors inherent to production and business management traits. Improving technical aspects such as pastures, herd genetics, production costs, equipment, and milk quality can affect the overall production factor. Additionally, the Management factor is influenced by the intention to improve administrative and technical processes, human resource management, the supply process, and the recognition of the farm in the market.

ACKNOWLEDGMENTS

This Project was financed by the Colombian National Fund for Science, Technology and Innovation "Francisco José de Caldas". Financial support was received from MinCiencias (Colombia, National Doctorates No. 727 of year 2015). The authors would like to thank Universidad de Antioquia and its sustainability strategy to GaMMA research group.

REFERENCES

- Adefulu AD. 2015. Promotional Strategy Impacts on Organizational Market Share and Profitability. *Acta Universitatis Danubius* 11(6): 20-33.
- Barrios D y Olivera M. 2013. Análisis de la competitividad del sector lechero: caso aplicado al norte de Antioquia, Colombia. *Innovar* 23(48): 33-4.
- Barrios D, Restrepo-Escobar FJ y Cerón-Muñoz MF. 2016. Antecedentes sobre gestión tecnológica como estrategia de competitividad en el sector lechero colombiano. *Livestock Research for Rural Development* 28(7):Article #125.
- Barrios D, Restrepo-Escobar FJ y Cerón-Muñoz MF. 2019. Adopción tecnológica en agronegocios lecheros. *Livestock Research for Rural Development* 31(8): Article #116.
- Bijl R, Kooistra SR and Hogeveen H. 2007. The profitability of automatic milking on dutch dairy farms. *Journal of Dairy Science* 90(1): 239-248. doi: 10.3168/jds.S0022-0302(07)72625-5
- Cangur S and Ercan I. 2015. Comparison of model fit indices used in structural equation modeling under multivariate normality. *Journal of Modern Applied Statistical Methods* 14(1): 152-16. doi: 10.22237/jmasm/1430453580
- Cerón-Muñoz MF, Gutiérrez-Zapata DM, Bolívar-Vergara DM, Bedoya GI y Palacio LG. 2015. Toma de decisiones basada en gestión de procesos: impacto en sistemas intensivos de producción de leche. *Livestock Research for Rural Development* 27(12): Article #245.
- Cerón-Muñoz MF, Corrales-Álvarez JD y Ramírez-Arias JP. 2017. Predicción de la producción de leche, porcentaje de grasa y proteína diaria a partir de registros del ordeño de la mañana o de la tarde en vacas Holstein en pastoreo. *Livestock Research for Rural Development* 29(9): Article #166.
- Cuartas-Martínez B, Barrios D and Cerón MF. 2018. Satisfaction among dairy farm owners after certification on good management practices. *Revista Facultad Nacional Agronomía Medellín* 71(3):8623-8630. doi: 10.15446/rfnam.v71n3.70287
- Cupani M. 2012. Análisis de Ecuaciones Estructurales: conceptos, etapas de desarrollo y un ejemplo de aplicación. *Revista Tesis* 2(1):186-199.
- Londoño C, Barrios D, Bedoya GI, Rodríguez H, Toro CA, Silva ML, Dávila MD, Pemberty P, Suárez P, and Palacio LG. 2016. Buenas prácticas ganaderas y gestión empresarial, mejoramiento del sistema productivo de las ganaderías de leche, carne y doble propósito, mediante buenas prácticas ganaderas en fincas pilotos del departamento de Antioquia. Primera edición. Fondo Editorial Biogénesis, Medellín. 76 p.
- Milán MJ, Arnalte E and Caja G. 2003. Economic profitability and typology of Ripollesa breed sheep farms in Spain. *Small Ruminant Research* 49(1):97-105. doi: 10.1016/S0921-4488(03)00058-0
- Múnera-Bedoya OD, Cassoli LD, Olivera-Ángel M y Cerón-Muñoz MF. 2018. Caracterización de sistemas de producción lechera de Antioquia con sistemas de ordeño mecánico. *Livestock Research for Rural Development* 30(5): Article #86.
- Pardo CE y Díaz OL. 2014. Desarrollo del talento humano como factor clave para el desarrollo organizacional, una visión desde los líderes de gestión humana en empresas de Bogotá D.C. *Suma de Negocios* 5(11): 39-48. doi: 10.1016/S2215-910X(14)70018-7
- R Core Team. 2018. A language and environment for statistical computing. Vienna, Austria.
- Revelle W. 2017. Psych: procedures for personality and psychological research (Software). Northwestern University, Evanston.
- Rodríguez H, Ramírez CJ y Restrepo LF. 2015. Factores que influyen la adopción de tecnología de gestión en producción lechera. *Temas Agrarios* 20(1): 36- 46.
- Rossee Y. 2012. Lavaan: An {R} package for structural equation modeling. *Journal of Statistical Software* 48(2):1-36.
- Russell RA and Bewley JM. 2013. Characterization of Kentucky dairy producer decision-making behavior. *Journal of Dairy Science* 96(7): 4751-4758. doi: 10.3168/jds.2012-6538

Sorge US, Moon R, Wolff LJ, Michels L, Schroth S, Kelton DF and Heins B. 2016. Management practices on organic and conventional dairy herds in Minnesota. *Journal of Dairy Science* 99(4): 3183–3192. doi: 10.3168/jds.2015-10193

Steenefeld W and Hogeveen H. 2015. Characterization of Dutch dairy farms using sensor systems for cow management. *Journal of Dairy Science* 98(1): 709-717. doi: 10.3168/jds.2014-8595

Steenefeld W, Tauer LW, Hogeveen H and Oude Lansink AGJM. 2012. Comparing technical efficiency of farms with an automatic milking system and a conventional milking system. *Journal of Dairy Science* 95(12): 7391-7398. doi: 10.3168/jds.2012-5482

Tse C, Barkema HW, DeVries TJ, Rushen J, Vasseur E and Pajor EA. 2018. Producer experience with transitioning to automatic milking: Cow training, challenges, and effect on quality of life. *Journal of Dairy Science* 101(10): 9599–9607. doi: 10.3168/jds.2018-14662

Vásquez-Jaramillo C, Barrios D y Cerón-Muñoz MF. 2018. Estudio exploratorio de la calidad de vida en el trabajo de ordeñadores de sistemas de producción de leche. *Archivos de Zootecnia* 67(258): 228-233. doi: 10.21071/az.v67i258.3658

Von Keyserlingk M, Martin N, Kebreab E, Knowlton K, Grant RJ, Stephenson M, Sniffen CJ, Harner JP, Wright AD and Smith SI. 2013. Invited review: Sustainability of the US dairy industry. *Journal of Dairy Science* 96(9): 5405–25. doi: 10.3168/jds.2012-6354