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The Application of RFID in Brazilian Harvest Facilities: Two Case Studies

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Abstract: *Using the two case studies presented in this work, this article aims to evaluate identification technology used in the Brazilian cattle market. Although Brazil possesses large companies in this sector (one of which is the largest exporter of meat in the world) some of them have yet to implement information technology (IT) for cattle identification purposes. Radio Frequency Identification (RFID) is an IT that identifies cattle using electronic ear tags. This particular form of technology is especially accurate and dependable as it can be used to trace a product from the origin of conception to the consumer. This paper utilizes a qualitative approach – two case studies – which were created with the application of a questionnaire (open and closed questions). Using RFID for internal control purposes only, each of the sample companies has limited use of the technology. Instead, these companies use barcode systems to trace and identify cattle and to send important information to their supply chain partners.*
Keywords: *Identification technology, RFID, evaluation, beef supply chain, harvest facility*

1. Introduction

In 2007, according to Rocha, A., (2009), Brazil exported 195.240 tons of meat *in natura* to the European Union (EU). This quantity decreased considerably the following year when the numbers were reduced to a mere 36.218 tons. The significant reduction can be explained by the imposed trade embargo that was put in place at the end of January, 2008. As a result of the trade embargo, Brazil's cattle supply chain industry experienced a loss of US$586 million. During this period, the European Union (EU) detected a number of flaws in the Brazilian cattle tracking system, and consequently reduced the number of meat supplier ranches.
The Brazilian cattle tracking system is comprised of many unique contributors including: the Ministry of Agriculture, producers, inspectors and certifiers, feedlots, harvest facility, retailers, research supporting foundations, and research institutions. In order to ensure the continued success and growth of Brazil's cattle market, the industry must maintain reliable traceability systems as demanded by the world's chief meat importers. In many instances, the use of Information Technology (IT) is limited among agents. Nonetheless, some ranches, harvest facilities, and retail companies have been reconsidering their choice of identification methods. Selecting the most appropriate identification method requires an investigation and assessment of the potential technologies to be used by an agent. A set of variables must be ranked by the agents in order to choose the most adequate method.

This paper endeavors to present a method, specifically in two harvest facilities (industries) via two case studies, which evaluates an identification technology used in the Brazilian beef chain. Beginning with the introduction, this article is separated into eight sections. The second component presents the Brazilian beef chain; the third outlines RFID use and the tracking system; the fourth describes a literature review on IT, Information System (IS), and RFID evaluation; the fifth presents the method; the sixth evaluates the results and discussions (including the case studies with rankings and comparisons); the seventh section presents the conclusions; and the last section lists the references.

2. Brazilian Beef Chain

The Brazilian beef chain can be divided into several stages, from the producers to the customers. The first stage refers specifically to animal production on ranches (beef cattle ranching and farming). In this phase, the rancher maintains much of the control over the cattle production and farming processes. The rancher must also cultivate and maintain a commercial relationship with the input industry, which includes supply companies related to mineral salt, medicine, vaccines, and cattle feed. The slaughter industry is responsible for purchasing the animals, slaughtering, cleaning, deboning, and packaging, as well as for meat sales. The slaughter industry trades animals directly with the ranchers through purchasing or sales sectors or by means of

intermediary agents (independent or representing the harvest facility) who conduct the transactions (Urso, F., 2007).

"Unfortunately, the tracking system in this productivity chain is defective. There exists a lack of integration that can result in disorganized regulatory documentation, which is required to prove that all steps of the cattle chain are well monitored and controlled. Final clients and consumers demand quality assurance at every stage of the complex system. Therefore, this poor coordination could involuntarily create a technical and/or sanitary barrier to market success. (Ribeiro P. et al, 2010)"

In accordance with Urso F. (2007), particularly in Brazil, food safety is a decisive factor when conducting agricultural business. Technical obstacles related to food safety and international trade are required to be in accordance with the Principles for Risk Analysis established during international agreements and must ultimately truly be justified.

"Regarding legislation, discussions are presently underway concerning ways in which to protect consumers from the unauthorized disclosure of their personal information. These proposed measures could help to prevent consumer harm, especially in countries where the RFID tracking systems have already been put in place. In fact, within a few sectors, these issues have delayed the implementation of useful technologies. (Ribeiro P. et al, 2010)"

3. Tracking Systems and RFID Use

Since tracking systems can recognize business operations, such as the ranches in which animals have travelled through, they are considered control methods. Additionally, in the event of an animal sanitation problem, they can precisely identify any responsible party.

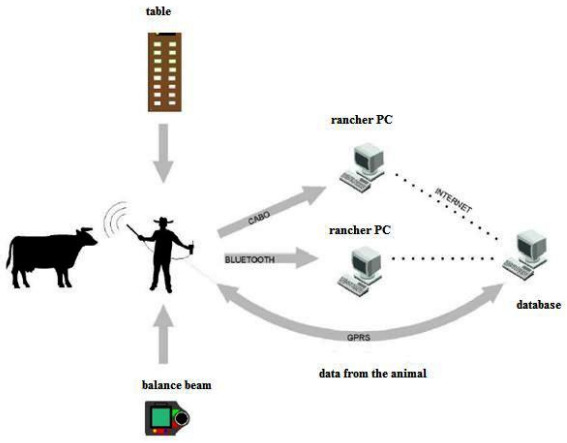

Fig. 1. RFID's tracking system (Ribeiro, P., 2007)

Two different ways to monitor animals, in order to track their path through the production chain, include the use of ear tags and rumen bolus (chip inserted into the animal). Ear tags contain the corresponding animal tracking number and barcode. The ear tag method is the least costly and most frequently used apparatus for identifying cattle in Brazil. By inserting a chip into an ear tag a RFID module can also be used.

The process begins when the ranch employee places the reader close to the animal ear, where the tag is. After, he or she chooses what data he or she wants to record on the system (a table where he or she types the data to read) or the animal is placed on the balance beam and its data are transferred to the rancher computers (PCs). Finally, the data recorded on the PCs is send by Bluetooth, GPRS or cable Internet (named cabo in Fig. 1) to the ranch database. The manager sends this data to the ranch clients (harvest facilities) by Internet (e-mail). Fig. 1 shows this data interchange:

It is worth noting that the use of RFID is limited due to cost factors (tags, antennas, readers) and to the operational changes that companies would be required to implement to support the new system. Additionally, in reference to the business environment, there are several aspects ranchers must consider prior to investing in RFID technology. These factors include: noise (wireless interference), control, dispersal material, and cost-benefit relations.

These technologies, specifically ear tags, are used to monitor the supply chain and are critical in providing the capability to track goods and to control inventories throughout the world.

4. Evaluation Models

In order to produce results, IT measurement processes have been updated to keep up with worldwide technological development. Despite the fact that IT is a continually growing and evolving field, investing in IT still presents risks. Therefore, in order to avoid unnecessary risks an effective evaluation policy, or a set of guidance policies, is required. Most risk factors indicate that IT investments do not significantly stimulate businesses strategies. What's more, other variables (organizational, security, technical) can enhance the risks associated with IT investments. Some authors have grouped these variables into models of evaluation of information, technology, IT, and SI. (Ribeiro, P., 2009; Ribeiro P. et al, 2010) This hierarchical format and the IT evaluation method are described in the following paragraphs.

5. The Three Variables

5.1. The Organizational Variables

'Organizational Variables' is the first group, which has been divided into four sub-groups: 'Relative Advantage', 'Compatibility', 'Observation Ability', and 'Key Objectives'. 'Relative Advantage' (Rogers, E., 1995) is related to the rate of technological innovation used by a company. Ranked according to the respondent's answers,

this variable includes: assurance that the business receives quality results (Sonnenwald, R. et al, 2001; DeLone, W. & McLean, E., 1992; Moore, G. & Benbasat, I., 1991; Agarwal, R. & Prasad, J., 1997), company support in order to meet goals (Sonnenwald, D. et al, 2001; DeLone, W. & McLean, E., 1992; Boynton, A. et al, 1994; Lewis, B. et al, 1995; Moore, G. & Benbasat, I., 1991; Agarwal, R. & Prasad, J., 1997), and the accomplishment and continuation of a high ranking in the market (Sonnenwald, D. et al, 2001; DeLone, W. & McLean, E., 1992; Clemons, E., 1991; Moore, G. & Benbasat, I., 1991; Agarwal, R. & Prasad, J., 1997).

'Compatibility' refers to company missions and objectives (Rogers, E., 1995). Information and Communication Technology (ICT) was evaluated according to its experience and contribution towards the group 'Communication' (Sonnenwald, D. et al, 2001; DeLone, W. & McLean, E., 1992; Bailey, J. & Pearson, S., 1983; Boynton A. et al, 1994; Moore, G. & Benbasat, I., 1991; Agarwal, R. & Prasad, J., 1997).

'Observation Ability' may also be referred to as 'Innovation Visibility', which can be used to indicate whether the technology used by a company in the supply chain provides visibility in the market (Rogers, E., 1995).

The fourth sub-group includes business 'Key Objectives', which was translated by Tallon et al (2000) into IT. Consequently, IT was evaluated as an advantage for effectiveness (DeLone W. & McLean, E., 1992; Bailey, J. & Pearson, S., 1983; Rivard, S. & Huff, S., 1984; Millman, Z. & Hartwick, J., 1987; Wang, Y. & Forgionne, G., 2008; Igbaria, M. & Tan, M., 1997; Petter, S. et al, 2008), reach (DeLone, W. & McLean, E., 1992; Boynton, A. et al, 1994), efficiency (DeLone, W. & McLean, E., 1992; Boynton, A. et al, 1994; Rivard, S. & Huff, S., 1984; Remus, W., 1984; Wang, Y. & Forgionne, G., 2008), and structure.

5.2. The Security Variables

Safety is one of the essential aspects of IT. Created to deal with IT security, the Information Technology Security Evaluation Criteria (ITSEC UK), is comprised of the following set of variables: availability, confidentiality, integrity (subdivided into data integrity and physical integrity by the authors), and consistency (DeLone, W., 1992). Regarding safety, IT was evaluated as a benefit for efficiency, effectiveness, structure, and reach.

Evaluated using the same scale as before, 'IT Security Variables' primarily considers: data integrity (Department of Trade and Industry, 1991; Bailey, J. & Pearson, S., 1983; DeLone, W. & McLean, E., 1992), physical integrity (Department of Trade and Industry, 1991; Bailey, J. & Pearson, S., 1983), availability (Department of Trade and Industry, 1991; Bailey, J. & Pearson, S., 1983; DeLone, W. & McLean, E., 1992; Srinivasan, A., 1985; Bradley, R. et al, 2006; Sedera, D. et al, 2004), consistency (Department of Trade and Industry, 1991; Bailey, J. & Pearson, S., 1983; DeLone, W. & McLean, E., 1992; Srinivasan, A., 1985; Bradley, R. et al, 2006; Sedera, D. et al, 2004; Ahituv, N., 1980; Petter, S. & McLean, E., 2009; Wang, Y. & Forgionne, G., 2008; Igbaria, M. & Tan, M., 1997) and most importantly – confidentiality (Department of Trade and Industry, 1991; Bailey, J. & Pearson, S., 1983; Lewis, B. et al, 1995).

5.3. The Technical Variables

The third group, 'Technical Variables' consists of: experimentation, reliability, technical aspects, complexity, environmental aspects, and economic aspects. Some of these variables can be further divided to better understand what they encompass. For instance, technical aspects can be understood as: variation (Deavours, D. et al, 2005; Morey, G., 1982), performance (Deavours, D. et al, 2005; DeLone, W. & McLean, E., 1992; Morey, G., 1982), quickness (Miller, J., 2007; DeLone, W. & McLean, E., 1992; Bradley, R. et al, 2006; Petter, S. & McLean, E., 2009; Igbaria, M. & Tan, M., 1997; Petter et al, 2008), conformity, and equipment quality (Miller, J., 2007).

The group, reliability, contains several variables – such as response speed – that can be used to evaluate IT (Sonnenwald, D. et al, 2001; DeLone, W. & McLean, E., 1992; Bailey, J. & Pearson, S., 1983; Srinivasan, A., 1985; Ahituv, N., 1980; Miller, J., 1987; Bradley, R. et al, 2006; Sabherwal, R. et al, 2006; Petter, S. & McLean, E., 2009; Petter, S. et al, 2008; Moore, G. & Benbasat, I., 1991).

Environmental aspects take account of 'closeness to water' in order to assess the resistance of RFID ear tags to various materials which may be present in areas where cattle are found (Miller, J., 2007; Deavours, D. et al, 2005).

Complexity (Rogers, E., 1995), can be evaluated to included both learning, and ease of system use. Experimentation, was divided into ease of recovering data (Sonnenwald, D., et al, 2001; Moore, G. & Benbasat, I., 1991), the effort required to use (Sonnenwald, D. et al, 2001; Sabherwal, R. et al, 2006; Petter, S. & McLean, E., 2009; Wang, Y. & Forgionne, G., 2008; Moore, G. & Benbasat, I., 1991) and learn the system (Sonnenwald, D. et al, 2001; DeLone, W. & McLean, E., 1992; Sabherwal, R. et al, 2006; Wang, Y. & Forgionne, G., 2008; Igbaria, M. & Tan, M., 1997; Petter, S. et al, 2008; Moore, G. & Benbasat, I., 1991; Agarwal, R. & Prasad, J., 1997).

Economical aspects include: profitability (Miller, J., 2007; DeLone, W. & McLean, E., 1992; Ein-Dor, P. et al, 1981; Rivard, S. & Huff, S., 1984; Hitt, L. & Bryjolfsson, E., 1996), risks involved (Sonnenwald, D. et al, 2001; Clemons, E., 1991), hardware (label) costs (Miller, J., 2007), the company budget (Miller, J., 2007), as well as other associated costs (Miller, J., 2007; Sonnenwald, D. et al, 2001; DeLone, W. & McLean, E., 1992; Clemons, E., 1991).

As part of the process of evaluating RFID, Deavours, D., (2005), investigated the number of performance indicators of a tag, such as variation/uniformity (operation disparities detected in tags of identical models), and productivity (the number of effectively working tags).

Comparing 12 different tag categories, Miller, J., (2007) included the following group of IT variables: cost, read

rate, technology maturity, quickness, effectiveness in noisy environments (noise can interfere with wireless technologies), and performance close to metal or water. Furthermore, the author divided the RFID performance evaluation into three sections: technical, economical, and environmental. Technical aspects of RFID include tag features, such as their accordance with available standards. Regarding economical aspects, the cost-benefit relations were considered and include: reducing data duplication (and errors), and reducing labor costs when necessary. On the topic of the environment, the author focused on noise, control, and dispersal material. Fig. 2 shows the final IT evaluation method:
The original research and evaluation method was applied to the beef chain identification technologies, such as barcode and RFID.

6. Method

The authors of this paper chose a qualitative research approach to describe the method. The method includes a case study in which detailed information was compiled, without generalizations, from two harvest facilities (Yin, R., 2001 and Bryman, A., 1989). Using an open and closed questionnaire, semi-structured personal interviews were conducted with the harvest facility managers. Yes-no questions were given and were ranked on a scale of 1 (very low) to 5 (very high). The case study 1 respondent was the quality farm manager. The case study 2 respondents were two ranch employees. One employee was responsible for customer service relations with regards to cattle raisers, while the other was the IT coordinator. For the purpose ofthis research, 2 employees were interviewed because they could both uniquely contribute to the questionnaire.
The evaluation variables (described in section 5) are the foundation of the IT evaluation method developed by the authors. However, in this instance, a more extensive review of the literature described in section 5 will be presented in another paper where the focus will be the method and its literature review and not the application as this paper.

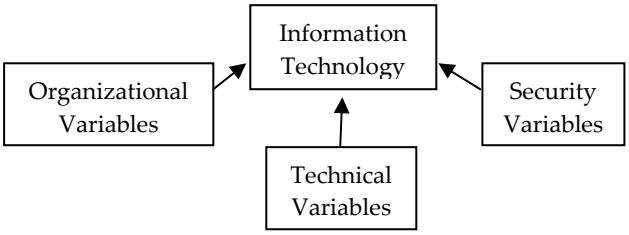

Fig. 2. IT evaluation method (adapted from Ribeiro, 2009)

It is of interest to note that some of the responses were omitted from the results in order to comply with the allocated number of pages per paper, as established by the editors. The study was effectuated between October 2006 and March 2008.

7. Results and Discussion

7.1. Case Study 1

The first case study (designated "Case 1") was carried out in a large-scale harvest facility, which conducts business abroad. The facility has a total of 73,000 employees, including the feedlot, industry, and headquarters. The company works on cultivating many partnership businesses, among which is a partnership with suppliers (raisers). For example, the suppliers are given information and technical assistance related to the partnership and they are paid extra money for taking part in a company partnership program. Additionally, organic products are responsible for the aggregate value. According to the respondent, not only does it benefit the harvest facility directly, it also contributes positively to the final product for the clients.
Despite infrastructure obstacles, IT provided more availability of information with the Internet's implementation in ranches. This implementation raised the integrity between ranchers and industries as well as the cattle's data that was being interchanged within the supply chain.
The company has an IT sector, with a corporate team, that coordinates all IT areas and units. Ultimately, the team is responsible for successfully communicating with the clients (internal users) and suppliers (IT, software, and hardware companies). In the order of implementation, the company's IT tools include: Intranet, Internet, barcode, ERP, EDI, RFID, and WMS. The total annual investments that the harvest facility made in IT are estimated at over $10,000.00 US dollars. The exact dollar amount was not accurately provided by the respondent.
Regarding the application of IT, the company makes use of barcode technology in the majority of its operations. They use RFID for internal operations only, such as controlling stock, storage, and pallets in which meat cuts are placed. Moreover, for internal management functions, the company uses a sensor to read the final product tag (after the deboning process). Interestingly, the material used for making tags is similar to that employed to manufacture CDs. However, due to the operations required to handle the pallets, the tag material is more resilient.

7.2. Case Study 2

Classified as "Case 2", the interviewees for this study include 2 employees of the harvest facility. This particular company is focused on trying to improve the quality of the raw material. As a means to this end, the company partnerships with its suppliers, such as cattle raisers. Pertaining to industrial automation, the company forms various partnerships with the intent to develop scales and harvest facility equipment. In accordance with the EUREPGAP, regarding aggregate value, the cattle are presently offered at a higher value than was previously obtainable.

Changes in information, due to IT, consist of increased security for the company and the dissemination of information used to establish a closer relationship between company sectors. This beneficial affiliation helps to increase the information exchange rate. What's more, according to the interviewees, the company has succeeded in achieving greater organizational integration with enhanced communication between the administration and operations.

The IT manager (for one data processing plant) within the company is the employee responsible for IT. Furthermore, the IT team is in charge of installing new technology. The total recent investments in IT that the company has made, and will make within the following three years, are over US$200,000.00. In order of implementation, the company IT tools consist of: Intranet, Internet, barcode, ERP, WMS, and RFID.

Regarding the tracking system, the business uses computers, barcode readers, antennas and RFID tags, as well as software for data processing (ERP). In addition, the company primarily makes use of identification technology, such as barcode, but does not employ transmission technology. RFID is used only in internal operations, such as the deboning conveyor. This is where the cattle are kept prior to the deboning stage, and where the use of barcode technology begins. The information contained within the barcode labels, applied to the boxes of meat, is shared through wireless Internet connections. This IT allows businesses to keep organized records, of the boxes being delivered to clients, in the company systems (physical and fiscal status via WMS). Furthermore, the cattle raisers can use the Internet to track the slaughter of the animals they sold to the harvest facility.

7.3. Case Studies Comparison

The most significant discrepancies based on average rankings will be compared in this section of the article. As a result of using a questionnaire that had open questions, some of the rankings will be evaluated solely based on the open responses.

It is important to note that there is a discrepancy in the rankings between the sub-variables "high rank achievement" and "maintenance". The respondents believed that the barcode tracking technology that they use does not help the company to earn market distinction. As a consequence, the Case 2 ranking was considered "low". In spite of this low ranking, the status of the sub-variable "visibility" was consistent with that of the "reach" variable. This is likely due to the fact that the Case 2 respondents regard the IT as still being beneficial for providing access to clients. However, "visibility" has been declining.

The respondents of Case 1 consider the technology that they use does not provide visibility. Nevertheless, since IT complies with sanitary requirements it helps both "market reach" and "stability" factors. Case 2 respondents ranked the variables "equipment quality" (barcode data reader) and "variation" (barcode labels) "very high" and "very low", respectively.

The "variation" category was considered "high" for Case 1, since the responses demonstrate discrepancies in the tags' performance. This same result did not occur in Case 2. Both Case 2 respondents acknowledged problems with the IT equipment; however, since the company has yet to investigate these issues, they can be deemed as being either transport or user problems.

The respondents from each of the two case studies proved to have differing opinions when it came to considering the variable "effort to use the system". For instance, Case 1 respondents believe that it is easier to use the barcode system than do those respondents from Case 2. This is likely because more time and training would have been necessary to use the IT system in this circumstance.

The respondents of Case 2 did not rank the sub-variable "confidentiality" because they believe that the implemented IT does not provide security. Consequently, the ranking of the sub-variable "risk" was greater in Case 2 than in Case 1. The respondents in Case 1 utilize barcode technology, which they do not consider unsafe because the company keeps its information confidential.

Both Case 1 and Case 2 participants were using RFID, but in different systems within their facilities. Case 1 was using RFID in warehousing operations, while Case 2 was using RFID during processing. Despite being at the same level of implementing the IT, they described diverse reasons for avoiding investing in RFID. Case 1 respondents had difficulty dealing with the RFID costs and the lack of information from the RFID suppliers regarding the system; hence, they did not show interest in any further implementation. Case 2 respondents did not intend to put into operation RFID for the short term. While the employees were collecting data from the cattle, they had problems with the barcode reader, which was the result of technical problems. Accordingly, they were waiting for new financial resources and technologies in which to invest in the long term.

Case 1 is one of the largest companies in Brazil and has significantly more resources (human, financial, technical) than the Case 2 company. Its managerial structure is also more advanced than that of Case 2. For example, the harvest facility is comprised of a group of managers, all of whom have a Master's Degree, which is the minimum requirement to be considered for the position. Case 2 is also a large company; but, unfortunately, it experienced some financial problems during 2009. This financial setback made it challenging to invest in IT.

In both cases the respondents did not know how to evaluate their IT according to financial or technical variables. It would be in the best interest of both companies to evaluate their IT in a different way. For instance, they should consider spending some time exploring the technical aspects of IT and not just the

financial side of the technology. Table 1 shows the comparison between these case studies:

Case Studies	Integrate	RFID	Reason	Evaluation
Case 1	ranchers and industries by Internet	internal operations: stock, storage, and pallets	Sanitary barrier the domestic market is demanding more control	all steps of ICT implementation, without any technique
Case 2	Ranchers and the company to improve the meat quality	internal operations, such as the deboning conveyor	Sanitary barrier differentiation	Just pre-implementation IS step

Table 1. Case studies comparison

8. Conclusion

Beginning with the second half of the 90's, the use of IT has become widespread among Brazilian companies. Yet, in the two case studies, the respondents' decision to use information technologies, such as RFID, has yet to be evaluated. The technology itself must first be evaluated

The Brazilian beef chain is comprised of a diverse configuration with both small and large companies in the same market. There are obvious differences when it comes to the management of harvest facilities and their use of IT – regardless of market participation or company size. Therefore, achieving integration amongst agents becomes increasingly challenging, which makes it more difficult to reach a joint decision. Ultimately, these joint decisions could help to optimize some operations along the productivity chain.

As an outcome of the world financial crises, debt interests have increased and the companies involved in this study have been experiencing fiscal losses and cash flow troubles. What is more, because of the lack of integration and cultural changes in the Brazilian cattle market, companies have failed to express interest in employing new IT's, such as RFID. This is likely the result of operational changes, higher costs, and the lack of information, evaluation, benefits analysis, and of government definitions related to the traceability demands for the external market.

The limitations of this research are related to: the financial data access, some companies did not allow their employees to participate on the interviews, and because RFID is not mandatory in the Brazilian tracking system, some data about its use did not exist.

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