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to improve inventory management: a case
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Academic literature about RFID shows that this technology has been steadily used as a tool by firms in their efforts to reduce costs and increase efficiency in the last decade. But the fact is that as of today, there are still many differences in terms of the degree of success in implementing RFID technology in different business environments. The main objective of this paper consists on identifying those variables that influence its successful implementation and handling, specifically in reducing inventory costs. To do so, we develop a case study of a fodder firm that has implemented in a very profitable way the RFID technology in its warehousing facilities.

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**RFID TECHNOLOGY AS A STRATEGIC TOOL
TO IMPROVE INVENTORY MANAGEMENT: A CASE STUDY**

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ABSTRACT

Academic literature about RFID shows that this technology has been steadily used as a tool by firms in their efforts to reduce costs and increase efficiency in the last decade. But the fact is that as of today, there are still many differences in terms of the degree of success in implementing RFID technology in different business environments. The main objective of this paper consists on identifying those variables that influence its successful implementation and handling, specifically in reducing inventory costs. To do so, we develop a case study of a fodder firm that has implemented in a very profitable way the RFID technology in its warehousing facilities.

1. INTRODUCTION

Even though the history of RFID began in 1948, when the technology was firstly used in WWII by the British army to distinguish its planes from those of the enemy, it was until the 90s, when this technology was for the first time widely used as a management tool. This happened with the deployment of electronic toll collection in the United States, and the installation of over three millions RFID tags on rail cars in North America (Landt, 2005, p.10).

The managerial interest about RFID has being growing in the last 20 years, something that is reflected in the academic literature. In particular, in the operations management literature, RFID constitutes a specific topic as of today. But certainly there are still many research gaps that still need to be addressed. We still need to know more about the implications of RFID on issues such as the strategic and operational design considerations, work/job design factors, educational requirement, the impact of RFID systems on inter-organizational supply chain relationships, and the barriers to and critical success factors of RFID adoption.

There is no doubt that RFID technology is a tool that may help firms to reduce costs and increase efficiency, but the fact is that there are many differences in terms of the degree of success related to the implementation of RFID technology, and this is precisely the main objective of this paper: to analyze the factors that are being instrumental in the successful implementation of this technology. To do so, we have developed a longitudinal case study of a food company that has implemented, in a very profitable way, the RFID technology in its warehousing facilities.

2. RFID IN THE LITERATURE

For this section, we have analyzed 38 academic articles related to RFID available in the period 2006-2008, and in parallel, we have used two previous examinations of the literature published: Chia-Chen Chao et al. (2006) and Ngai, et al., in the “International Journal of Production Economics”. In total, we made a review of the published material that covers a period of time that goes from 1991 to 2008. From this assessment we can derive a certain number of conclusions. In the first place, we think that technology is already established and well known: the number of articles devoted to show the functioning and technological advances related to the use of RFID had decreased. From being 36.5% of the total published in 1995-2005 to only 2.6% in 2006-2008. Secondly, the number of articles published on matters related to implementation issues have grown to a total of 71.1% in 2006-2008 (from 32.9%). Third, we have found that there are, in relative terms, few articles dedicated to what we call private policy issues that the use of RFID implies. In other words, articles devoted to matters like privacy, security or standardization are less numerous, and this may be so because the use of RFID has been focused on obtaining and tracing data of products and raw materials, more than about end-consumers. 5.3% of the articles were written as a general introduction (from 11.8%) and 15.8% of the articles were about the coming trends in the use of this technology.

On the other hand, in the review we found many cases of the way in which RFID has been implemented and used in many different sectors, both in manufacturing and services firms. The largest numbers of cases were examples of the way in which RFID has been used in Distribution (i.e., Delen et al., 2007), Construction (i.e., Wang et al., 2007) and Hospitals (i.e., Tzeng et al., 2008).

Finally, we have considered the articles in terms of the area of the firm in which RFID has been employed. In 2006-2008, 26% of the papers dealt with inventory management including warehousing (i.e., Bottani and Rizzi, 2008), 23% with the improvement of manufacturing processes (i.e., Gaukler and Hausman, 2008), and 20% with the productivity of workers (i.e., Lee et al., 2008). Other areas were traceability (14%), the use of RFID to exchange information with other members of the Supply Chain in order to explore the advantages related to the implementation of a traceability system (i.e., Ngai et al., 2007), and finally, 9% on other logistic activities (i.e., Holmqvist and Stefansson, 2006).

3. DESCRIPTION OF THE FIRM

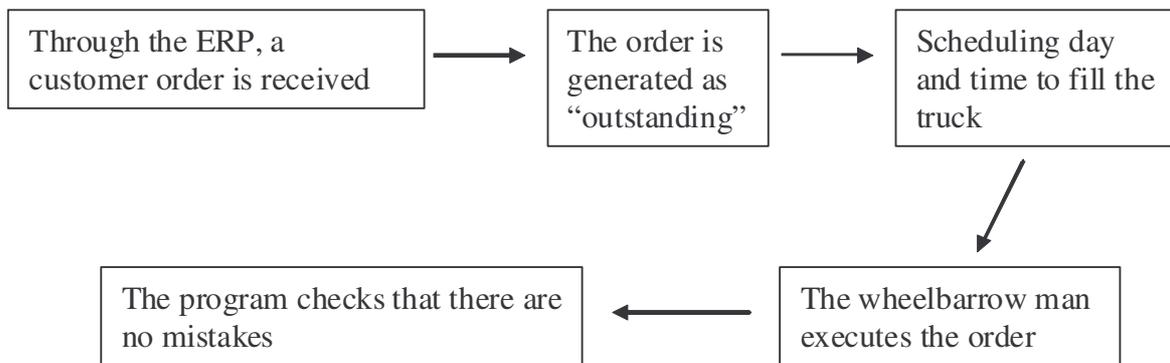
DV¹ is a firm located in the province of Guipuzcoa (Spain). Its main activity is the manufacturing and distribution of food for cattle. The customers of DV are wholesalers that sell the products to farmers. Presently, the company's business includes the manufacturing, packaging and commercialisation of products. The variety of finished products is extensive, as well as the packaging. The volume of sales is about 6 million euros and about 10 people work in the firm.

It is important to be acquainted with the information flow that goes from the point in which an order from a customer is received by DV, to the moment it is dispatched. This procedure is described in Figure 1. From this process, there are two aspects that are mostly relevant: on the one hand, DV uses an ERP to receive the orders, which implies that the system is employed by their customers and used to share information, which is a key factor to get relevant advantages from RFID; the second aspect is the role played by the wheelbarrow man to implement the order in a right way. As we mentioned later,

¹ DV is not the true name. The firm whose activities we describe has asked us to remain anonymous.

the task performed by this employees is extremely important for the successful implementation and use of the RFID technology.

Figure 1. Information flow in DV associated to a customer order.



In 2007, the firm began to use an information system developed by a consulting firm that worked with DIVA SAT for many years. This fact tightened the relationship between both firms which end up being an association based more on trust at a personal level than the merely typical business relationship. Because of this, when the general manager of the consulting firm offered the owner of DV, the possibility of implementing RFID technology in their logistics activities, he promptly accepted.

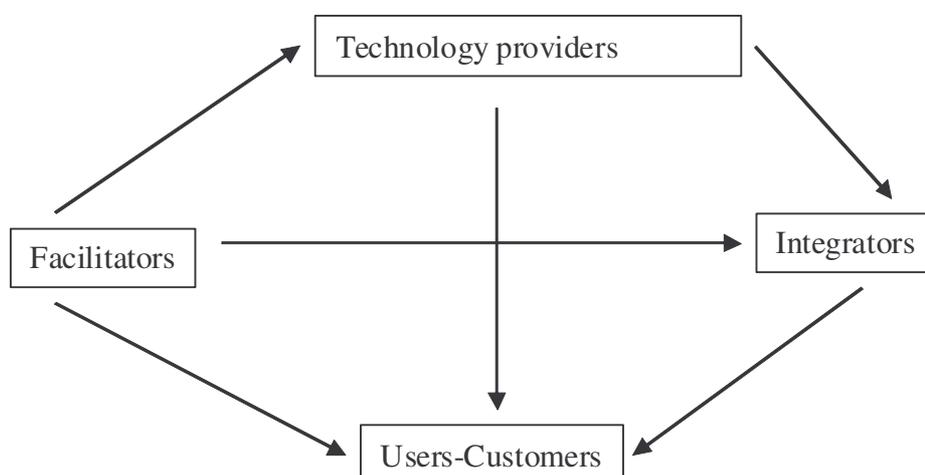
4. METHODOLOGY

For this project, we have performed a longitudinal case study research. In order to do so, we have adopted case study methodology considerations (Yin, 1984; Miles and Huberman, 1994; and Voss et al. 2002), as well as particular recommendations for a longitudinal case like this one (Leonard-Barton, 1995; Pettigrew, 1995; and McPhee, 1995). Case Study is a research methodology widely used and basically recommended

to study phenomena that take place in rich contexts where there are always many variables to consider in comparison to the number of observations to be made.

For this case study research, we have followed a multi-stage process. First, we chose the firm to be analyzed. We took advantage of previous research done by the authors about RFID (Alfaro et al., 2009) and from previous interviews with firms and institutions that make up what we call the “supply chain network related to RFID implementation”, (see Figure 1). Technology providers and user-customers are intuitively easy to define. In the case of integrators, they are usually consulting firms specialized in writing software for TICs, as well as the management of all the implementation procedures. In this sense, it is quite common, that the introduction of RFID is related to its integration in an ERP platform. About facilitators, this role is usually played by certain type of institutions, usually public in the sense that they have being developed using government local or state funds, whose main objective is to improve the competitiveness of a region and/or an industry. Therefore, these institutions have a deep knowledge of the industrial sector in which RFID is going to be implemented, as well as the understanding of the mechanisms to get the financial resources that may help in the implementation of this kind of projects.

Figure 2. Supply Chain Network related to RFID implementation.



Building on these considerations and the interviews we have carried out, we soon realized that DV was one of the most interesting firms in order to analyze the implementation of RFID technology in logistics activities. Knowing the facilitator as well as the technology provider, granted us access to different informants and a way in to internal documents and materials.

Data collection began in October 2008 and concluded in January 2010. Along this period of time, we interviewed employees of DV as well as from the integrator and the technology provider, something crucial in order to determine the factors that influence the degree of success of a project like this one. The in-depth interviews were done using a semi-structured questionnaire and were always performed by two members of the team in order to make possible the comparison of notes and interpretations. The interviews lasted an average of two hours.

With the purpose of enhancing the internal validity of the case study, we used different informants (triangulation), took our tentative interpretations back to the people from whom they were derived asking them if the results were plausible, and requested colleagues to comment on our findings. The fact that we did a long term observation of the same phenomenon made possible the gathering of data over a period of time, something that, in our opinion, served to increase the internal validity of the investigation.

Since the term reliability in the traditional sense seems an oddity when applied to qualitative research, to increase reliability, Lincoln and Guba (1985) suggest thinking about the dependability or consistency of the results obtained from the data. In this sense, rather than demanding someone else to obtain the same results as ours, (the definition of reliability), we tried to make the outcomes of this research as consistent and dependable as possible. For this reason, much like an audit trail, we made a final

interview to make a presentation of our findings to the top managers of the firms. From this meeting, some clarifications were made, and included in this article. Finally, it is necessary to emphasize the fact that the authors of the study have published other articles based on case study methodology, which shows that it is a methodology they clearly domain (i.e. and Alfaro and Rábade, 2009).

5. WHY & WHEN RFID TECHNOLOGY MUST BE IMPLEMENTED

To establish the circumstances that motivate a firm to think about implementing RFID technologies, it is crucial to understand the variables that determine its success. Dew and Read (2007) established three mechanisms for the diffusion of technology. The first one is leadership. Leaders can be extremely useful in organizing a dispersed set of actors. Wall Mart is one of the most cited examples of a firm that performs as a leader to make its suppliers incorporate RFID technology in their processes. In this instance, it is also relevant to notice the role played by retailers and logistics firms in order to pull from their suppliers and customers

DV is not an end-consumer, nor a distributor, or a logistic operator, something that makes his case especially relevant in order to study the reasons why this firm took the initiative to implement RFID technology as part of its operations. The second reason is focal points. There are different kinds of focal points: psychological, cultural and historical. In the case of focal points, the diffusion of RFID in US was based on the extended use of the Electronic Product Code (EPC). The third reason is common knowledge. In Spain, the mechanisms employed to generalize the understanding of this technology are related to the role of facilitators (see Figure 1), which are institutions like associations of firms, public firms that through certain mechanisms of diffusion like

conferences, lectures and White papers, aimed to potential users, try to enhance the interest for future investments in technologies like RFID.

For DV, the key element to understand the reason why the firm implemented RFID technology was the role played by the integrator. This consulting firm, specialized in writing software for TICs, was in charge of managing all the implementation process. As in DV, it is very usual the introduction of RFID is associated to the use of an ERP, whose implementation was also carried out by the integrator. In this way, RFID is connecting to a better exploitation of the potential benefits of an ERP platform. This model is common for small and medium firms (SMEs); in the one hand, it is so because SMEs usually do not need a high number of transponders, so there is no need to negotiate with large suppliers of electronic gadgets; on the other, normally, the standard technology does not fit exactly with this kind of firms, so there is a need to look for specific solutions, something that requires the services of an integrator in order to smooth the whole process. These factors make this implementation process be rather expensive for an SME. Because of this, the integrator must also search opportunities in order to obtain funds to subsidize the whole project.

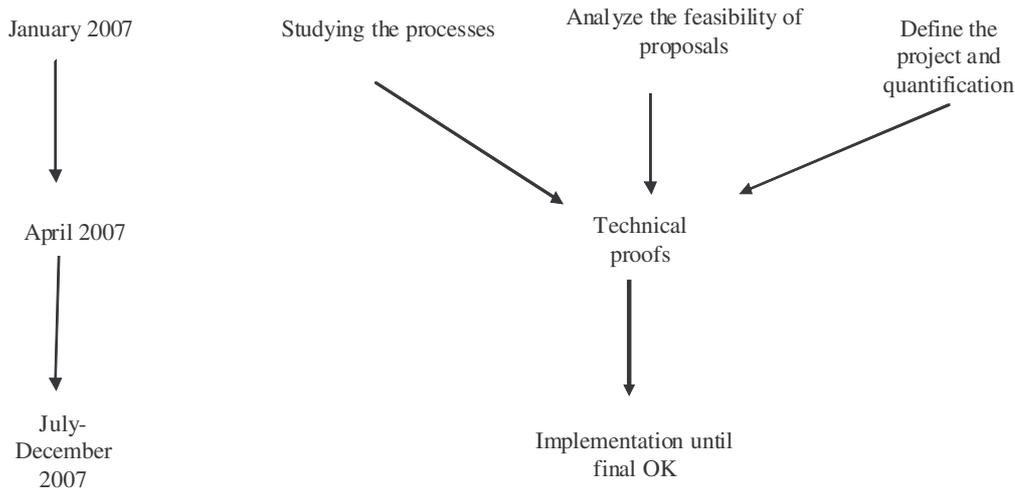
6- KEY ASPECTS OF THE IMPLEMENTATION PROCESS

DV began the implementation process of its traceability system in January 2007, as it is described in Figure 3.

At the very beginning, DV went through a detailed analysis of their procedures in order to find out those features that needed to be improved. This was done promptly because the consulting firm that carried out the process had a wide knowledge of the firm due to their previous business relationship. Through the *feasibility of proposals*, the firm pointed out that the pallets were homogenous, that is, that only one reference needed

was the one linked to the pallet. Traceability and cost are key concerns for DV's customers; because the tag contains all sort of useful information for them, this was instrumental in order to take the decision to implement this technology.

Figure 3. Stages in RFID implementation in DV.



The definition and quantification of the project phase implies that the return of investment (ROI) must be calculated, as well as the financial resources that are going to be saved by customers. It is important to put a figure on the investment in both hardware and software terms. It is also relevant to determine the period of time needed to recover the investment, and the way the new technology is going to influence the methods used by employees to handle their duties.

Certainly, all these is very time consuming, but in the implementation of this kind of ventures, all details must be taken into account because it is quite common to change some fine points, minutiae that, at the end, have a deep influence on the total cost of the project.

Speaking about *technical proofs*, we must say that this stage took in DV about three months. DV had to buy and install all the necessary antennas, readers and tags, and had

to develop the software needed to read the data from the antennas and transmit it to the ERP platform. Finally, the last step, the *implementation until final OK*, was the longest one. This fact delayed the whole process, something that consumed more money which was to be paid by the consulting firm-, and more time and physical resources, something that DV had to deal with. As an example, one of the problems that had to be coped with was the deterioration of tags because the way the pallets were manipulated at shop level. It was solved by wrapping the tags and changing their location in the pallets.

As shown in Table 1, the analysis of the DV case study allows us to identify four barriers for the successful implementation of RFID. The first factor that the analysis of this case permits us to define as crucial in the implementation of RFID technology is the *background of previous experience* of the agents involved in the whole process. In the project in which DV was involved, the trust developed by the technology provider who had some experience in RFID implementation. The fact that DV had a tight relationship with the integrator, and the fact that the integrator trusted the technology provider fundamental: sometimes the project was in the verge of being cancelled due to different delays along the life span of the endeavour.

Table 1. Main obstacles for the RFID implementation in DV.

Obstacles	How to solve them	DV ways to overcome the situation
No previous experience	Trust in the integrator	Offer a personalized project
Reduce cost investment	Find the right processes to implement RFID	<ul style="list-style-type: none"> - Warehousing and inventory processes - Homogenous pallets - Pallets return to the firm
Large process	Assume costs and resources by all the involved actors	Be sure that the efforts will compensate the consumption of resources
Attitude of employees	Involve them in the proofs	Choose the “right” person to leader the project and convince the wheelbarrow men

About *the investment cost*, we have to remind that DV is a SME, so even having a positive ROI, the truth is that for this kind of firms, an investment cost too high, may determine the termination of the implementation process. Because of this, it is critical to determine the units in which the tags will be post. In this project, the technology provider tagged the pallets and isolated warehousing and inventory from the rest of DV operations. This decision lowered the investment cost and raised the ROI for the project. The *length of the process* is also an extremely important variable in the implementation process. In the case of DV, it took about one year, something that was a real risk for the final OK. The fact that all the deviation costs were handled by, both, the integrator and

the technology provider, and the fact that the user-customer was convinced that the technology was going to be positive were the main reasons that kept the project running, in spite of the delays, especially in the final stages of the implementation process. (see Figure 2). Talking about the *attitude of employees*, we have already described it in a previous section. We emphasized the role played by the wheelbarrow men in the information flow in DV operations. Because of this, the reluctant attitude of these operators regarding the use of RFID technology was an obstacle that the integrator and the technology provider had to overcome. That the person in charge of the project was chosen not because of his expertise in technology, but because of his personal attitude and his leadership capabilities with the rest of the employees, was crucial for the final OK.

7. ADVANTAGES OBTAINED FROM RFID TECHNOLOGY IN DV

The benefits of the RFID technology for DV have been ample and diverse, and have had an influence in all the activities that encompass the DV supply chain. But certainly warehousing, inventory management, and distribution have being the processes more beneficiated, both qualitative and in quantitative terms in the whole flow of DV operations.

About warehousing and inventory management, Table 2 shows the improvements reached in these areas.

Inefficiencies and problems in warehousing and inventory have been drastically reduced. In this sense, DV has better operational procedures and utilises their resources in a more efficient way. For example, now the firm uses less warehousing space, and has lowered their stock outs.

Table 2. Benefits of RFID in warehousing and inventory management.

	Qualitative benefits	Quantitative benefits
WAREHOUSING AND INVENTORY MANAGEMENT	<p>Operators are happier in the work</p> <p>Working with frozen products is specially expensive</p>	<p>Less errors in the lecture of lots</p> <p>Reduce obsolescence costs</p> <p>Reduction of safety stocks</p> <p>No stock outs</p>

About distribution aspects, with the RFID tool, costs have been significantly reduced. Today, in DV there are less delivery errors, and the firm has less refunds and breakage costs. Currently, DV keeps a record of every reference; tracks all pallets from each one of its different customers; and knows exactly how and when each final product is delivered to each one of its customers. As it can be shown in Table 3, the RFID technology has allowed DV to increase their chances for acquiring larger and more demanding clients.

It is fair to say that RFID allows DV to have a total control of their products. The firm has improved the rotation of their stocks and optimised its warehousing space; it has reduced the workforce employed per shift and decreased the inventory level. With all these, the productivity of the warehousing force have being re-examined. DV has also optimised the way the products are delivered to their customers and has reached a more efficient use of their distribution system.

Table 3. Benefits of RFID in distribution.

	Qualitative benefits	Quantitative benefits
DISTRIBUTION	<p>Increase the trust of customers in DV</p> <p>Increase the portfolio of customers</p>	<p>Reduction in devolution of lots</p>

8. SUMMARY

The most relevant findings associated to this paper are related to different aspects related to RFID implementation. First, to show *the relevance of the integrator* as the key actor to get a firm uses RFID. It is relevant to emphasize as the relationship between both firms is based more on personal relationships than business ones. Second, the analysis of DV case study permits identifying *four obstacles for the successful implementation of RFID*: previous experiences, cost investment, length of the implementation process and attitudes of employees. Third, *the benefits of the RFID technology* for DV have been ample and diverse, and have touched all the activities that encompass the DV supply chain, but especially from warehousing and inventory management, and distribution. DV has upgraded all their operations both from a qualitative and a quantitative perspective. Improvements are associated to three factors: traceability, activities of employees and inventory benefits.

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