A LITERATURE REVIEW ON THE IMPACT OF INVENTORY DATA RECORD INACCURACIES ON INVENTORY MANAGEMENT AND THE POTENTIAL OF THE RFID TECHNOLOGY TO TACKLE THIS ISSUE

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Abstract: The impact of the use of RFID on supply chain operations has been explored in several investigations. One of the main benefits of RFID that is identified by these studies is its ability to improve visibility in supply chains by enabling a better synchronization between the physical flow of goods and the information flow representing it. In this work, our focus is steered on data record inaccuracies that lead to discrepancies between these two flows in inventory systems (warehouses or distribution centers); our aim is to present an overview of investigations that examine the inventory data inaccuracy issue and explore the way that this issue can be tackled by using an advanced item identification and data capture system such as RFID.

Key words: inventory record inaccuracies, RFID, supply chain management

Introduction:

Nowadays, more and more companies use several systems such as enterprise resource planning, supply chain execution or warehouse management systems in order to plan and control their material flows effectively. Many of these systems have, however, yielded poor results due to the unavailability of accurate information. It is therefore critical to the success of these companies to have accurate information on the identity, status and location of entities (items, cases or pallets) during the various transactions that take place in their supply chains.

One of the main questions practitioners face today is how to justify the investments that enable to improve visibility in supply chains. Nevertheless, there is still little research in the supply chain management literature that deals with this issue. Recently, there has been a renewed interest in this topic due to the development of advanced data capture technologies such as the RFID technology. To our knowledge, in the literature exploring the RFID technology, besides research related to the technical aspects of the technology (hardware, software, languages, etc..), several investigations have been conducted on how companies can benefit from the use of RFID as an enabling technology to support more intelligent automation and control (for instance, [1] discusses how flow shops can be adapted by intelligent software agents making distributed decisions meanwhile, [2] highlights the impact RFID technology will have in materials handling systems) and improved operations in supply chains.

In this paper, our attention is focused on studies that aim to quantify the benefits of RFID on supply chain management. Among these benefits, there are improvements such as the reduction in waiting times, the acceleration of supply chain flows or the elimination of non value adding material handling activities that are quantifiable quite easily. There are other types of benefits for which a simple modeling approach may not be enough, meaning that more sophisticated analyses should be carried out. Assessing the benefit that would stem from having more accurate information on the identity, quantity and location of products stored in an inventory is an example of such benefits. The focus of our paper is on this specific point, namely, we are seeking an answer to the question “how can we measure the value of item level information provided by this new technology in managing inventory systems?”.

The investigations that have been developed in the inventory data inaccuracy literature focus on one or a combination of the four following points: (1) examining the parameters that influence the impact of inaccuracies on product availability and other supply chain performance measures (2) studying the root causes of inventory inaccuracy and their influence on supply chain performance (3) determining appropriate inventory counting policies (when to conduct inventory counts, how many products to count) (4) determining how to adjust safety stocks and replenishment policies in order to adjust for inventory inaccuracies. Our aim is to provide an overview of investigations pertaining to this stream of literature. Our paper is organized as follows: section 1 begins with presenting examples of investigations that model the business value expected from technologies that are used in supply chains in general. This is followed by an overview of the literature that is interested in quantifying the benefits stemming from the use of the bar code technology in particular. Section 2 proposes a review of the quantitative investigations dealing with the inventory inaccuracy issue: we begin by classifying these investigations and then provide a brief description of some models developed. Finally Section 3 concludes the paper.

1 Evaluating the Benefits of Using Technologies in Supply Chains:

1.1 Assessing the Business Value of Technologies Used in Supply Chains in General

As global competition intensifies in response to tougher trading conditions, supply chain members from manufacturer to retailer are striving to attain process efficiencies that enable them to drive down costs and provide competitive advantage. [3] states that technologies have the potential to support the information flow and affect many of the dimensions of supply chain management such as cost, quality, delivery, flexibility and ultimately profits of the firm. They support the communication and coordination of the economic activities between separate units of an organization and collaboration along the supply chain by enabling better information processing, sharing [4] and faster responsiveness by making available online, real-time information networked around the organization and giving full supply chain visibility. Therefore, since 1998, companies have spent $14.9 billion on supply chain software; for instance, automotive manufacturers spend roughly 60% of their IT budgets for the improvement of their supply chain management systems [5].

Supply chain managers, seeking evidence that technology investment efforts produce better firm performance, have faced the following questions: (1) what are the operational gains accrued by supply chain actors? Does the technology pay off? (2) How can we quantify the benefit?

Investigations developed to quantify the benefits of deploying a technology are either case oriented empirical studies or quantitative models including financial models, simulation, stochastic models or heuristics. For instance, some researchers have examined the positive effect of IT/IS investments on firm productivity ([6]) by proposing a general modeling framework or by conducting empirical studies ([7]). Several quantitative methods using traditional financial approaches such as payback period, return on assets, return on investment, discounted cash flow methods ([8]), return on equity ([9]), net present value (NPV) analysis ([10]) have also been used for selecting new technologies. One of the main problems when trying to apply one of these financial techniques for assessing a particular investment seems to be the difficulty in identifying and measuring the expected benefits of a proposed technology. Business process modeling and simulation are mechanisms used by several authors for experimenting with alternative investments, assessing the benefits introduced by particular system and process configurations, and helping the management to take decisions concerning investments ([11]).

Other authors have formulated the investment decision as a mathematical model built upon well known operations management models. For instance, [12] develops a model for the justification of the acquisition of a new technology by evaluating its effect on the inventory setup costs in a lot size reorder point (r,Q) model. [13] proposes a multi-objective mathematical model for the effective acquisition and justification of IT/IS for supply chain management, the main contribution of this paper being the development of a multi-objective mathematical model that effectively incorporates cost, quality, flexibility and time goals. [9] presents an approach to investigate the effects of IT on technical efficiency in a firm's production process through a two-stage analytical study with a firm-level data set.

In addition to these investigations, other types of methodologies have also been proposed. For instance, authors such as [14] have applied system dynamics. This technique is relatively easy to apply, accommodates subjective judgment and change, and leads to improved system specifications. However, we argue that it is not rigorous enough to support low level analysis and assessment. Moreover, a detailed modeling is difficult or impossible given the existing formalism and software tools [14].

Finally, [15] addresses the recent developments in the application of fuzzy concepts to IT/IS justification processes while [16] proposes interpretative approaches which include exploratory methods and meta-methodologies.

1.2 Assessing the Benefits of the Bar Code Technology

The bar code system is among data capture technologies that have been widely used in almost every industry. By leveraging the barcode technology, the grocery industry, for instance, was able to realize hard and soft savings of 2.76% and 2.89% respectively (as percentages of revenue).

Typical goals in implementing a bar code system (and more generally Automatic Identification and Data Capture systems) are the reduction of data capture errors, the capture of timely data for inventory control, an enhanced communication between buyers and sellers and the improvement of customer service ([17]). [18] adds that contemporary Automatic Identification and Data Capture systems must provide discipline and control that is based not only upon plans and performance goals, but also upon the dynamics of actual operations: these systems are the major source of real-time feedback, they allow businesses to monitor operations, manage resources, and flag anomalies before they impact throughput.

bar codes originated in the food sector as the cornerstone technology to automate the check out process and in that way, reduce labor costs as well as cash register errors. It was not until the 1983-1987 period that bar code usage spread to sectors served by mass retailers like Kmart and Wall Mart.

Several investigations have been conducted on how supply chains can benefit from bar code applications. This includes qualitative research that explains the concept of the bar code technology and develops conceptual methods in an effort to better understand it. Most of time, results developed are validated within the context of case studies with enterprises. An example of such a study would include [19], which, based on ten case studies carried out in distribution and manufacturing companies, show how the bar code system can enhance inventory management performance. In all cases, the system, mostly used for work in process tracking and shipment control (which ensures that the right product is shipped to the right customer) has enhanced the performance of the company, but quantitative results are not available. Among results achieved are less capital tied up in inventory, enhanced inventory control, enhanced customer service and empowered employees. [20] develops a conceptual framework for the integration of a bar code system in inventory and marketing information systems using the barcode technology as an enabler for effective supply chain management. Problems, benefits and solutions regarding the integration of the bar code technology are examined in the context of a case study. [21] shows how batch processing is currently a major drawback in industrial applications and emphasizes the role of Radio Frequency systems integrated to technologies of automatic identification, bar-coding, and automatic data capture in increased inventory accuracy and timeliness of real-time data pertaining to internal and external logistics transactions. Main results obtained in a very large distribution center are increased productivity, higher accuracy of the amount and pallet location, reduced cost of material handling.

More sophisticated investigations on the impact of the bar code technology have been realized with a specific interest on the inventory inaccuracy issue. For instance, [22] discusses on mechanisms used in bar code equipped facilities to track and correct errors creating mismatches in inventory records. He argues that these activities should be realized in order to investigate and correct the cause of the error rather than simply correcting a number in the system.

2 The Inventory Data Inaccuracy Issue in Supply Chains:

2.1. Description of the Problem

The quality of information pertaining to the characteristics of products is one of the biggest problems currently faced by supply chain management. For example, according to [23], an average of 30% of information in retailer systems is incorrect, and other studies show that as much as 63% of product descriptions can diverge in supplier and wholesaler systems. In a study conducted for the Grocery Manufacturers of America, A.T. Kearney Inc. estimates that retailers and manufacturers each lose $2 million for every $1 billion in sales due to bad data. They predict that eliminating bad data could save $10 billion per year [24].

The literature in the field of inventory management is vast. However, the common assumption underlying most research is that data gathered from physical transactions are accurate so that the physical flow is perfectly aligned with data stored in inventory information systems. Based on recent empirical observations, this implicit assumption has proven to be wrong. In fact, based on a study done with a leading retailer, [25] report that out of close to 370,000 SKUs investigated, more than 65% of the inventory records did not match the physical inventory at the store-SKU level. Moreover, 20% of the inventory records differed from the physical stock by six or more items.

In practice, inventory inaccuracies can be introduced by several factors generating a misalignment between the physical flow and the associated information flow:

– Theft: this factor affects the physical inventory level and let the Information System inventory records unchanged.

– Misplacement type errors: this type of errors affects temporally the physical available for sales inventory and let the IS inventory unchanged.

– Transaction type errors: transaction errors affect the IS inventory and let the physical inventory unchanged.

– Supplier unreliability (i.e. underages /overages in products shipped by supplier): those errors may affect both the IS and the physical inventory if no control is performed when receiving the order.

Among existing works that investigate the impact of such inventory inaccuracies, [26] focuses on how inaccurate work in process counts can distort the effectiveness of an MRP system. He explains reasons why to maintain accurate work in process inventory system records and develops a framework to describe the different sources of inaccuracies: errors usually stem from system structure problems, system discipline problems, process variability problems, measurement problems and quality related problems.

Among the other examples illustrating the magnitude of the problem is [27] that reports that the Naval Supply Depot using the Master Stock Record history of a sample of 714 items from the 20 000 line item types stocked there, found that 25% of the item types had accumulated discrepancies that exceeded 24 units after one year. It also found the distribution of accumulated errors to be closely approximated by a normal distribution.

As presented earlier, the study of [25] also reveals that a large retailer with annual sales of roughly $ 11 billion from more than 1500 stores worldwide estimates a profit loss of $ 32 million annually due to its inventory record inaccuracy problem. According to a store level analysis, 65% of nearly 370 000 inventory records from 37 stores of a large retail chain are inaccurate at the time of the physical inventory audit. Moreover, for 15% of these records, the absolute difference between system inventory and actual inventory quantity per SKU was eight or greater. This study identifies the magnitude and drivers of poor inventory records and provides an empirical study of inaccurate inventory records in a retail store at both record and store levels. It is reported that the probability of an inventory record being accurate can be predicted by product's characteristics such as item cost or whether the item is risky or not, annual units sold, the entity delivering this item or material flow characteristics such as the complexity of pallets received / to be prepared (multiple product pallets or homogeneous pallets), etc..

[28] develops a similar analysis: he finds that 36% of 200 000 inventory records sampled from several distribution centers of an organization with a large logistical operation were inaccurate.

[29] suggests that differences between accurate and inaccurate inventory records are associated with item cost, use of weight counting for inventory tracking and the number of different storage locations for a particular item. According to their analysis, low value, high volume items are most likely to be in error.

2.2. Impact of inaccuracies on Inventory Management

The existing investigations in inventory management that deal with inventory inaccuracies can be classified based on several criterions:

(1) *the objective of the investigation*:
i.e. some investigations try to evaluate the impact of inventory inaccuracies through empirical studies (or through simulation analysis) while other investigations try to optimize the replenishment policy being used in the inventory system which is subject to inaccuracy problems.

(2) *the structure of the supply chain considered (warehouse/retail store or centralised/decentralised supply chain)*: from an inventory control point of view, the difference between the two contexts stems from the fact that (*i*) in a retail store, the customer demand is confronted to the physical available for sales inventory since the customer is physically present in the retail store (*ii*) in a warehouse context, customer demand is satisfied based on the Information System inventory where a commitment is done based on the level observed in the IS inventory in the first step. Then, this commitment is confronted to the physical inventory when delivering the order. As a consequence, in a warehouse context, there exists an additional underage penalty that does not occur in a retail store.

The second point associated with this criterion concerns the number of actors considered in the supply chain. In a centralized supply chain, a unique decision maker is concerned with maximizing the entire supply chain's profit whereas, in a decentralized supply chain two or more actors act as different parties and each one tries to maximize his own profit.

(3) *the nature of errors causing inventory inaccuracies:*
without any anomalies in the expected physical materials flow, the amount of goods available in an inventory system would increase each time an expected replenishment is received and decrease each time a demand is satisfied. These movements of stock can be qualified as known inputs and known outputs. But, because of the existence of several unknown outputs and inputs (such as theft, misplaced items or supplier unreliabilities), the real physical flow differs from the nominal one. A perfect synchronization between the physical flow and the associated data which is recorded in information system enables to verify if events happened as planned (without any product losses, overages or delays) and to identify the reasons of deviations. This synchronization is possible only if all transactions (i.e. known transactions as well as unknown transactions) are detected by the information system. If this is not respected, the information system inventory diverges from the physical inventory level leading to inaccuracies.

The existing investigations that address the inventory inaccuracy issue are models that combine the criterions presented above. While the complete analysis of this literature can be found in [30] and [31], the remaining part of the paper gives a brief description of some of the investigations developed so far.

2.2.1. Investigations evaluating performance in presence of inventory inaccuracies

Inventory management deals with inventory planning and control. An inventory control policy is characterized by the answers it provides to the two basic questions: (i) when to order? (ii) how many products to order? As explained earlier, some of papers are interested in evaluating the effect of inventory inaccuracies for a predefined inventory policy rather than optimizing the parameters of this policy:

– In presence of inventory miscounts, when the lead time is variable, the realized service level, measuring parts availability from shelf, is much lower than the prescribed service level. [32] develops quantitative measures for the evaluation of the degradation in service level in a continuous review (r,Q) inventory policy as a function of the level of inventory miscount and the lead time variability.

– [27] also evaluates the poorer service level resulting from inaccuracies and performs a sensitivity analysis of this measure to several actions (faced with the inaccuracy issue, managers may act in different ways; i.e. increase the safety stock; increase the frequency of inventory counts or initiate efforts to pinpoint the sources of the errors and reduce them) that improves it.

– [33] focuses on the individual impacts of different types of inaccuracies (e.g. theft, unsaleables, poor process quality) on the performances of a supply chain (monetary or non-monetary measures). They use simulation and variance analysis (Anova) as research method. They consider two settings; in the base case, they set up a supply chain where information on end consumer demand is available to all echelons in real time, and the physical flow is perturbed by several factors. Then they modify the model so that physical inventory and information system records are aligned in each time period and compare the two models. In the base model, inventory information becomes inaccurate due to low process quality, theft, and items becoming unsaleable. In the modified model, these factors that cause inventory inaccuracy are still present, but physical inventory and information system inventory are aligned at the end of each period. They found that elimination of inventory inaccuracy can reduce supply chain costs as well as out of stock level.

2.2.2. Investigations optimising inventory policies in presence of inventory inaccuracies

[34] proposes a mathematical model which determines an optimal frequency for periodical inventory taking processes within a supermarket. Deviations in inventory records tend to decrease with increasing frequency of a periodical inventory taking process and thus the total loss incurred also decreases as the frequency of a periodical inventory taking becomes large. However, when the inventory taking frequency increases, the total cost for periodical inventory taking activities increases. The expected cost per unit time is formulated, considering the cost for inventory taking activities and the investigation cost for the causes of deviations.

The investigation of [30] provides a comprehensive analysis of potential errors that may occur within an inventory system with a special focus on reasons why mismatches occur between the physical flow and the information flow representing it. She builds a general Newsvendor framework to model the impact of errors in order to quantify the cost penalty they generate and evaluates if the implementation of an advanced data capture technology such as RFID is cost justified. In particular, in [36], the authors derive analytically the optimal inventory policy in presence of errors, when both demand and errors are uniformly distributed. Results demonstrate that the expression of the optimal quantity to order is not simple and for reasonable error parameter values, can deviate from being linear.

[35] and [37] are among investigations where inventory inaccuracies are mainly introduced by transaction type errors. To our knowledge, [35] is the first paper that discusses the inventory inaccuracy problem in a quantitative manner, the

objective being to select the type and frequency of counts and to modify the predetermined stocking policy by adding a buffer to cover for errors so as to minimize the total cost (inventory holding + inventory counting cost) per unit time subject to the probability of errors not depleting this buffer between inventory counts does not exceed a prescribed level. Their setting is a single-item, periodic-review inventory system with a predefined stationary stocking policy. In other words, they do not consider establishing an optimal replenishment policy. Instead they take the control policy such as (s, S) as given.

[37] study the inventory replenishment problem with a counting policy of an inventory system subject to transaction errors. As in [35], the authors assume that transaction error random variables are additive and are identically and independently distributed with zero mean. In particular, they consider a periodic-review, stationary inventory system in which transaction errors accumulate until an inventory count. The manager incurs a linear ordering, holding and backorder cost and a fixed cost per count. The objective is to decide whether to count or not and how much to order to minimize the total cost of ordering and counting.

[38] is among the rare studies that provide an optimization procedure for an inventory system subject to misplacement, shrinkage and transaction errors. The investigation considers a finite horizon, periodic-review inventory control problem in which inventory records are inaccurate. In order to model the inventory inaccuracy issue, the total demand is grouped under four streams: paying customer, misplacement, shrinkage and transaction error. Misplacement, shrinkage and transaction errors are undetected between consecutive inventory audits without a technology such as RFID. These error terms accumulate until a physical inventory count takes place. The manager performs a physical counting of inventory. After the inventory audit, misplaced items are returned to inventory, accumulated error terms are set to zero, and the on-hand inventory record is set equal to actual on-hand inventory. The authors establish an inventory control policy when the manager observes the actual inventory movement. They establish an inventory control policy that can be used when the system is RFID enabled. Second, to assess the value of prevention in addition to visibility provided by RFID, they model the special case in which the misplaced items are returned to stock at the end of each period. Next, they provide a model and a policy that does not use RFID technology but can partially compensate for the inventory discrepancy problem. They further model the imperfect visibility case in the presence of errors due to RFID readings. At the end of their paper, they conduct a numerical study and compare the models with and without RFID and quantify the value of RFID.

[39] use analytical and simulation based modeling to demonstrate how theft type errors increase lost sales and result in an indirect cost of losing customers (due to unexpected out of stock) in addition to the direct cost of losing inventory. They consider a (r,Q) inventory policy where a store replenishment is perturbed by a random theft. Even when the theft rate is as small as 1% of the average demand, the error accumulating in the inventory record is large enough to disturb the replenishment process and make 17% of the total demand lost. They also observe a continual rise in the gap between the IS inventory and the physical inventory and show that the system reaches a point where the inventory record stays above the reorder point *r* and the consequence is that no order is placed. The authors refer to this situation as the replenishment freeze. In the second part of their paper, the authors propose several compensation methods in order to reduce the effect of the inventory inaccuracy issue, among which RFID.

2.2.3. Investigations introducing RFID as a lever to improve the accuracy of inventory records

Among investigations described before, some of them introduce explicitly the use of the RFID as a lever to improve accuracy (see for instance [30], [38], [39], etc.). In these studies, RFID is presented as a technology which either reduces or prevents errors. The cost pertaining to the implementation of RFID is often introduced as being a variable cost associated with tagging each individual unit of products.

Among these investigations that consider the use of RFID, some of them analyze specifically how in a decentralized supply chain structure with two actors, costs that stem from implementing RFID should be distributed among supply chain partners. In practice, it is often argued that while manufacturers are generally most interested in tracking cases or pallets of products, retailers are expected to gain the most benefit from individual product tracking on their shelves. Hence, [40], [41], [42] and [43] are among studies that have been developed in order to propose contract mechanisms which ensure that net profits are achieved by all supply chain members once RFID is implemented in decentralised two-level supply chains consisting of a supplier and a retailer.

3. Conclusion:

In this paper, we presented an overview of investigations that have been conducted on how companies can benefit from the use of RFID as a lever to improve the accuracy of inventory data records. Such studies enable to asses one part of gains achieved by deploying RFID but are not representative of the overall benefits since, as reported in [44], the implementation of this technology can also lead to other types of benefits such as the reduction of information asymmetries and the incentive problems arising between a downstream and an upstream party; the acquisition of advanced knowledge about actual lead times experienced in the supply chain; the increase in supply system security, etc.

We think that quantitative models that consider the effect of RFID on supporting reverse logistics or on planning supply chain activities are of special interest. While the need for further investigation concerning the first point is accelerated by the recent governmental regulations that imply the recycling of most of consumer goods such as electronics or pharmaceuticals, the second point refers to the ability of RFID to support the implementation of a decentralised approach when planning supply chain activities.

References:

1-McFarlane, D.; *Auto-ID Based Control: An Overview*; Technical Report; Auto ID Center; 2002 May.

2-García, A., McFarlane, D., Fletcher M. and Thorne A.; *Auto-ID in Materials Handling*; Technical Report; Auto ID Center; 2003 May.

3-Brandyberry, A., Rai, A., and White, G.P.; *Intermediate performance impacts of advanced manufacturing systems: an empirical investigation*; Decisions Sciences; 1999; Vol. 30.

4-Shin, N.; *Does information technology improve coordination? An empirical analysis*; Logistics Information Management; 1999; Vol. 12(1/2).

5-Alexander, K., Gilliam, T., Gramling, K., Kindy, M., Moogimane, D., Schultz, M. and Woods M.; Focus on the Supply Chain: Applying Auto-ID within the Distribution Center; Technical Report; Auto ID Center; 2002.

6-Brynjolfsson, E. and Hitt, L.; *Paradox lost? Firm level evidence on the returns to information systems spending*; Management Science; 1996 April: p. 541-58.

7-Ross, A.; *A multi-dimensional empirical exploration of technology investment, coordination and firm performance*; International Journal of Physical Distribution & Logistics Management; 2002; Vol. 32(7): p. 591-609.

8-Turner, J.; Organizational performance, size and the use of data processing resources; Center for Research in Information Systems, New York University; 1985.

9-Shao, B.M. and Lin, W.; Technical efficiency analysis of information technology investments: a two-stage empirical investigation; Information & Management; 2002; Vol. 39: p. 391-401.

10-Rouwenhorst, B., Reuter, B., Stockrahm, V., Van Houtum, G.J., Mantel R.J. and Zijm, W.H.M.; Warehouse design and control: Framework and literature review; European Journal of Operational Research; 2000; Vol. 122: p. 515-533.

11-MacArthur, P.J., Crosslin, R.L., and Warren, J.R.; A strategy for evaluating alternative information system designs for business process reengineering; International Journal of Information Management; 1994; Vol. 14: p. 237-51.

12-Keller, G. and Hamid, N.; Justifying New Technology Acquisition Through its Impact on the Cost of Running an Inventory Policy; IIE Transactions; 1998; Vol. 20(3).

13-Talluri, S.; An IT/IS acquisition and justification model for supply-chain management; International Journal of Physical Distribution & Logistics Management; 2000; Vol. 30(3/4).

14-Wolstenholme, E., Henderson, S., and Gavine, A.; The Evaluation of Management Information Systems: A Dynamic and Holistic Approach; 1993; Wiley.

15-Sharif, A.M. and Irani, Z.; Research note: theoretical optimization of IT/IS investments; Logistics Information Management; 1999; Vol. 12(1/2): p. 189-96.

16-Walsham, G.; Interpreting Information Systems in Organizations; 1993; Chichester; John Wiley & Sons.

17-Trunk, C.; Using bar codes for warehouse control; Material Handling Engineering; 1994; Vol. 49(10): p. 48-52.

18-Hill, J. and Cameron, B.; Automatic Identification and Data Collection: Scanning Into the Future; Ascet; 2000; Vol. 2.

19-Lindau, R. and Lumsden, K.; The use of automatic data capture systems in inventory management; International Journal of Production Economics; 1999; Vol. 59.

20-Manthou, V. and Vlackhopoulou, M.; Bar-code technology for inventory and marketing management systems: A model for its development and implementation; International Journal of Production Economics; 2001; Vol. 71.

21-Yao, A.C. and Carlson, J.G.; The impact of real-time data communication on inventory management; International Journal of Production Economics; 1999; Vol. 59(1-3).

22-White, E.; The root cause of the problem; Apics the performance advantage; 2002 February.

23-UCCnet; The Value of Clean Data; 2003; available on http://knowledgebase.uccnet.org/press-Room/publications.

24-Meeting the retail RFID Mandate; Technical Report; AT Kearney; 2003 November.

25-Raman, A., DeHoratius, N., and Ton, Z., Execution: The missing link in retail operations. California Management Review; 2001; Vol. 43:136–152.

26-French, R.L.; Accurate WIP Inventory- a critical MRP System Requirement; Production and Inventory Management; 1980; Vol. First Quarter.

27-Morey, R.C.; Estimating Service Level Impacts from changes in cycle count, buffer stock or corrective action; Journal of Operations Management; 1985; Vol. 5(4).

28-Millet, I.; A Novena to Saint Anthony, or How to Find Inventory by Not Looking; Interfaces; 1994; Vol. 24(2).

29-Sheppard, G. and Brown, K.; Predicting Inventory Record Keeping Errors with Discriminant Analysis: A field experiment; International Journal of Production Economics; 1993; Vol. 32(1).

30-Sahin, E., A qualitative and quantitative analysis of the impact of Auto ID technology on the performance of supply chains; PhD thesis; 2004; Ecole Centrale Paris.

31-Rekik, Y., The impact of the RFID technology in Improving Performance of Inventory Systems subject to Inaccuracies; PhD thesis; 2006; Ecole Centrale Paris.

32-Kumar, S. and Arora, S.; Effects of Inventory Miscount and non inclusion of the lead time variability on inventory system performance; IIE Transactions; 1992; vol. 24, no2.

33-Fleisch, E. and Tellkamp, C., Inventory inaccuracy and supply chain performance: a simulation study of a retail supply chain. International Journal of Production Economics, 2005, 95/3.

34-Sandoh, H. and Shimamoto, H.; *A theoretical study on optimal inventory taking frequency for retailing*; Journal of Retailing and Consumer Services; 2001; Vol. 8.

35-Iglehart, D. and Morey, R.C.; Inventory systems with imperfect asset information; Management Science; 1972; Vol. 18(8).

36-Sahin, E., Buzacott, J. and Dallery Y., The Impact of Inventory Record Inaccuracies on the Newsvendor with Uniformly Distributed Demands; Technical Report; 2005; Ecole Centrale Paris.

37-Kok, A. G. and Shang, K., H., Replenishment and inspection policies for systems with inventory record inaccuracy; Technical Report, 2004, Fuqua School of Business, Duke University.

38-Atali, A., Lee, H., and Ozer, O., If the inventory manager knew: Value of RFID under imperfect inventory information; Technical Report, 2005, Graduate School of Business, Stanford University.

39-Kang, Y. and Gershwin, S. B., Information inaccuracy in inventory systems - stock loss and stockout. IIE Transactions, 2004; Vol 37: 843–859.

40-Gaukler, G., Seifert, R.W., and Hausman, W.H.; *Item level RFID in the retail supply chain*; Technical Report; 2003; Standford University.

41-Uckun, C., Karaesmen, F., and Savas, S., Investment in improved inventory accuracy in a decentralized supply chain; Technical report, Department of Industrial Engineering, 2005, Koc University.

42-Rekik, Y., Jemai, Z., Sahin, E. and Dallery Y., Improving the Performance of Retail Stores Subject to Execution Errors: Coordination Versus RFID Technology, Technical Report, 2005, Ecole Centrale Paris.

43-De Kok, A.G., Van Donselaar, K.H., Van Woensel, T., A Break-even Analysis of RFID Technology for Inventory sensitive to Shrinkage, Technical Report, 2006, TU/e Eindhoven University of Technology.

44-Lee, H. L. and Ozer, O., Unlocking the value of RFID. Technical Report, 2005, Stanford University.