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Improved supply chain performance through RFID technology: comparative case analysis of Metro Group and Wal-Mart

Omar Massuod Salim Hassan Ali

University of Wollongong

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Improved Supply Chain Performance through RFID Technology: Comparative Case Analysis of Metro Group and Wal-Mart

Omar Massuod Salim Hassan Ali

This thesis is presented as part of the requirements for the award of the Degree of Master of Information Systems Technology
University of Wollongong

December/2012
ABSTRACT

Introducing RFID technology into retail industry enhances and increases the speed, accuracy, detailing and visibility of operational information updates for specific units of business production. This research examines the impact of RFID technology on supply chain (SC) performance. It focuses on RFID technology and its implementation at two retail chains in the United States (US) and Europe which have successfully implemented this technology, and identifies the impact of RFID technology on improving SC performance in the retail industry. This study has examined a wide range of research literature and secondary data sources. The researcher has concentrated on both explorative and indicative studies in an effort to understand the impact that the adoption of RFID technology will have on improving the performance of the SC by comparing two different case studies. This study has found that coordination and integration operations are important for inventory management and related operations and they are also important factors which contribute to performance improvement in both case studies. In addition, this study has found that RFID’s information-sharing support for buyers in the SC has promoted the accuracy of purchasing forecasts. Finally, it is found that RFID has provided increased flexibility of operations, using smart shelves and reducing the cost of inventory management.

This study concludes that the implementation of RFID technology helps retail SC perform the operational process as well as resource visualisation. A limitation of this research was the use of secondary sources rather than the adoption of a primary data collection approach, which latter would have provided a real-time representation of current RFID implementation. Future research could focus on the comparison of three or four case studies in order to arrive at more detailed and supported recommendations.
ACKNOWLEDGEMENTS

It is difficult to overstate my deep gratitude to my research supervisor Dr. Akemi Chatfield. With her enthusiasm, inspiration and great efforts to explain things clearly and simply, she helped me overcome a lot of obstacles during the research period. I would have been lost without her encouragement and sound advice.

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I am also wish to thank my beautiful and loving wife for her support and encouragement, and also my patient daughter Fatima Ezhra and my son Ali for their amusing questions and their smile.

Lastly, and most importantly, I wish to thank my parents Massoud and Fatima. They bore me, raised me, supported me, taught me and love me.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC</td>
<td>Activity Based Costing</td>
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<tr>
<td>ACM</td>
<td>Association for Computing Material</td>
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<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>ASIC</td>
<td>Application Specific Integrated Circuit</td>
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<tr>
<td>Auto ID</td>
<td>Automatic Identification</td>
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<tr>
<td>BSC</td>
<td>Balanced Score Card</td>
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<tr>
<td>CPFR</td>
<td>Collaborative Planning, Forecasting, and Replenishment</td>
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<tr>
<td>CRM</td>
<td>Customer Relationship Management</td>
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<tr>
<td>DOD</td>
<td>Department of Defence</td>
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<tr>
<td>DSS</td>
<td>Decision Support System</td>
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<tr>
<td>EAS</td>
<td>Electronic Article Surveillance</td>
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<td>ECR</td>
<td>Efficient Customer Response</td>
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<td>EDI</td>
<td>Electronic Data Interchange</td>
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<td>EECC</td>
<td>European EPC Competence Centre</td>
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<tr>
<td>EFQM</td>
<td>European Foundation for Quality Management</td>
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<tr>
<td>EPC</td>
<td>Electronic Product Code</td>
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<tr>
<td>ERP</td>
<td>Enterprise Resource Planning</td>
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<tr>
<td>FMCG</td>
<td>Fast Moving Consumer Goods</td>
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<tr>
<td>GMA</td>
<td>Grocery Manufacturers of America</td>
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<td>GSCF</td>
<td>Global Supply Chain Forum</td>
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<tr>
<td>HF</td>
<td>High Frequency</td>
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<tr>
<td>IABS</td>
<td>Inspection Adjusted Base-Stock</td>
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<tr>
<td>IC</td>
<td>Integrated Circuit</td>
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<tr>
<td>ID</td>
<td>Identification</td>
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<tr>
<td>IOS</td>
<td>Inter-Organizational System</td>
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<tr>
<td>IP</td>
<td>Internet Protocol</td>
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<tr>
<td>IS</td>
<td>Information System</td>
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<td>ISO</td>
<td>International Organization for Standardization</td>
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<td>IT</td>
<td>Information Technology</td>
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<tr>
<td>JIT</td>
<td>Just-in-time</td>
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<td>KPI</td>
<td>Key Performance Indicator</td>
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<td>LF</td>
<td>Low Frequency</td>
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<tr>
<td>Acronym</td>
<td>Full Form</td>
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<tr>
<td>MF</td>
<td>Microwave Frequency</td>
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<td>MGB</td>
<td>Metro Group Buying</td>
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<td>MGL</td>
<td>Metro Group Logistics</td>
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<tr>
<td>MSA</td>
<td>Mobile Shopping Assistant</td>
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<tr>
<td>NLIS</td>
<td>National Live Stock Information System</td>
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<tr>
<td>OCR</td>
<td>Optical Character Recognition</td>
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<tr>
<td>OOS</td>
<td>Out-of-Stocks</td>
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<tr>
<td>PBL</td>
<td>Problem Based Learning</td>
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<td>POS</td>
<td>Point-of-Sale</td>
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<td>PSA</td>
<td>Personal Shopping Assistant</td>
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<td>RF</td>
<td>Radio Frequency</td>
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<td>RFID</td>
<td>Radio Frequency Identification</td>
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<td>RISB</td>
<td>Richard Ivey School of Business</td>
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<tr>
<td>R/W</td>
<td>Read/Write</td>
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<tr>
<td>SASC</td>
<td>Strategic Audit Supply Chain</td>
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<td>SC</td>
<td>Supply Chain</td>
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<td>SCC</td>
<td>Supply Chain Council</td>
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<td>SCM</td>
<td>Supply Chain Management</td>
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<td>SCO</td>
<td>Supply Chain Orientation</td>
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<td>SCOR</td>
<td>Supply Chain Operations Reference</td>
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<tr>
<td>SKU</td>
<td>Stock Keeping Units</td>
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<td>SPM</td>
<td>Strategic Profit Model</td>
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<td>SSCM</td>
<td>Sustainable Supply Chain Management</td>
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<td>TCP</td>
<td>Transmission Control Protocol</td>
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<tr>
<td>UHF</td>
<td>Ultra-High Frequency</td>
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<tr>
<td>UPC</td>
<td>Universal Product Code</td>
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<tr>
<td>VMI</td>
<td>Vendor-Managed Inventory</td>
</tr>
<tr>
<td>WMS</td>
<td>Warehouse Management System</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS

1 INTRODUCTION.................................................................................................................. 1
   1.1 Research Background .................................................................................................. 1
   1.2 Research Objectives ................................................................................................ 3
   1.3 Thesis Structure ....................................................................................................... 4

2 TECHNOLOGY BACKGROUND .................................................................................. 5
   2.1 Barcode Technology ................................................................................................ 5
   2.2 Radio Frequency Identification Technology (RFID) ............................................. 5
      2.2.1 Standards ........................................................................................................ 6
         2.2.1.1 EPCglobal ............................................................................................. 6
         2.2.1.2 ISO ........................................................................................................ 7
      2.2.2 The major RFID components ............................................................................ 8
         2.2.2.1 Tag (Transponder) ................................................................................ 8
         2.2.2.2 Reader (Interrogator) .......................................................................... 11
         2.2.2.3 Antenna ............................................................................................... 11
         2.2.2.4 Computer (Backend system) ................................................................ 12
      2.2.3 Frequencies ....................................................................................................... 12
         2.2.3.1 Low Frequency ..................................................................................... 12
         2.2.3.2 High Frequency ..................................................................................... 12
         2.2.3.3 Ultra-High Frequency ......................................................................... 13
         2.2.3.4 Microwave Frequency ....................................................................... 13
      2.2.4 Current issues facing RFID technology ......................................................... 14
   2.3 Comparison of RFID and Barcode ......................................................................... 14

3 SUPPLY CHAIN PERFORMANCE LITERATURE REVIEW .................................. 15
   3.1 Supply Chain Management .................................................................................... 15
   3.2 Supply Chain Performance ................................................................................... 18
      3.2.1 Measuring the performance of supply chain ............................................... 19
      3.2.2 Intricate performance measures in a supply chain ....................................... 20
      3.2.3 Competitive priorities of the supply chain .................................................. 25
      3.2.4 Supply chain fit: Implications for service management ............................... 26
   3.3 Supply Chain Performance Evaluation Models ................................................ 26
      3.3.1 Characterization of different supply chain performance evaluation models ... 26
         3.3.1.1 Balanced Score Card .......................................................................... 27
         3.3.1.2 Supply Chain Operation Reference Model .......................................... 27
         3.3.1.3 Global Supply Chain Forum .................................................................. 28
         3.3.1.4 Strategic Audit Supply Chain ............................................................... 29
         3.3.1.5 Global EVALOG .................................................................................. 29
         3.3.1.6 AFNOR FD X50-605 .......................................................................... 30
         3.3.1.7 Efficient Customer Response ............................................................... 30
         3.3.1.8 Strategic Profit Model ......................................................................... 30
      3.3.2 Application of SC tool of service industry and retail sector .......................... 31
   3.4 Framework Analysis ............................................................................................. 32
      3.4.1 Cost ................................................................................................................. 32
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.2</td>
<td>Quality management</td>
<td>33</td>
</tr>
<tr>
<td>3.4.3</td>
<td>Time</td>
<td>34</td>
</tr>
<tr>
<td>3.4.4</td>
<td>Information sharing</td>
<td>34</td>
</tr>
<tr>
<td>3.4.5</td>
<td>Flexibility</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>RESEARCH METHODOLOGY</td>
<td>37</td>
</tr>
<tr>
<td>4.1</td>
<td>Research Process</td>
<td>37</td>
</tr>
<tr>
<td>4.1.1</td>
<td>Research philosophy</td>
<td>37</td>
</tr>
<tr>
<td>4.1.2</td>
<td>Research approach</td>
<td>38</td>
</tr>
<tr>
<td>4.1.3</td>
<td>Research strategy</td>
<td>38</td>
</tr>
<tr>
<td>4.1.4</td>
<td>Data collection</td>
<td>39</td>
</tr>
<tr>
<td>4.2</td>
<td>Sources of Secondary Data</td>
<td>40</td>
</tr>
<tr>
<td>4.2.1</td>
<td>Criteria for inclusion</td>
<td>42</td>
</tr>
<tr>
<td>5</td>
<td>RFID AND ITS IMPACT LITERATURE REVIEW</td>
<td>47</td>
</tr>
<tr>
<td>5.1</td>
<td>RFID Technology</td>
<td>47</td>
</tr>
<tr>
<td>5.2</td>
<td>Empirical Evidence of RFID’s Impact</td>
<td>49</td>
</tr>
<tr>
<td>5.2.1</td>
<td>Empirical evidence of RFID in retail sector</td>
<td>51</td>
</tr>
<tr>
<td>5.2.2</td>
<td>Empirical evidence of RFID in logistics providers</td>
<td>52</td>
</tr>
<tr>
<td>5.2.3</td>
<td>Empirical evidence of RFID in manufacturing</td>
<td>53</td>
</tr>
<tr>
<td>5.2.4</td>
<td>Empirical evidence of RFID in whole supply chain</td>
<td>53</td>
</tr>
<tr>
<td>6</td>
<td>CASE STUDIES</td>
<td>55</td>
</tr>
<tr>
<td>6.1</td>
<td>Metro Group – Case Study 1</td>
<td>56</td>
</tr>
<tr>
<td>6.1.1</td>
<td>Metro Group history</td>
<td>56</td>
</tr>
<tr>
<td>6.1.2</td>
<td>Metro Group and RFID</td>
<td>57</td>
</tr>
<tr>
<td>6.1.2.1</td>
<td>Drivers of implementing RFID</td>
<td>58</td>
</tr>
<tr>
<td>6.1.2.2</td>
<td>Overview of implementing stages</td>
<td>58</td>
</tr>
<tr>
<td>6.1.3</td>
<td>Metro Group Future Store Initiative</td>
<td>61</td>
</tr>
<tr>
<td>6.1.4</td>
<td>Metro Group RFID innovation centre</td>
<td>65</td>
</tr>
<tr>
<td>6.1.4.1</td>
<td>RFID in picking</td>
<td>66</td>
</tr>
<tr>
<td>6.1.4.2</td>
<td>RFID in warehouse management</td>
<td>66</td>
</tr>
<tr>
<td>6.1.4.3</td>
<td>RFID in the department store</td>
<td>66</td>
</tr>
<tr>
<td>6.1.4.4</td>
<td>RFID in the supermarket</td>
<td>66</td>
</tr>
<tr>
<td>6.1.4.5</td>
<td>RFID in the private household</td>
<td>67</td>
</tr>
<tr>
<td>6.1.5</td>
<td>Benefits experienced by Metro Group due to RFID</td>
<td>67</td>
</tr>
<tr>
<td>6.1.6</td>
<td>Metro Group Services</td>
<td>70</td>
</tr>
<tr>
<td>6.1.6.1</td>
<td>Metro Group Logistics</td>
<td>70</td>
</tr>
<tr>
<td>6.1.6.2</td>
<td>Metro Group Buying</td>
<td>71</td>
</tr>
<tr>
<td>6.2</td>
<td>Wal-Mart – Case Study 2</td>
<td>72</td>
</tr>
<tr>
<td>6.2.1</td>
<td>Wal-Mart history</td>
<td>72</td>
</tr>
<tr>
<td>6.2.2</td>
<td>Wal-Mart operations</td>
<td>73</td>
</tr>
<tr>
<td>6.2.3</td>
<td>Wal-Mart and IT</td>
<td>73</td>
</tr>
<tr>
<td>6.2.4</td>
<td>RFID at Wal-Mart</td>
<td>75</td>
</tr>
<tr>
<td>6.2.4.1</td>
<td>Drivers of implementing RFID</td>
<td>75</td>
</tr>
<tr>
<td>6.2.4.2</td>
<td>Overview of implementing stages</td>
<td>76</td>
</tr>
<tr>
<td>6.2.5</td>
<td>Benefits experienced by Wal-Mart due to RFID</td>
<td>78</td>
</tr>
<tr>
<td>6.3</td>
<td>Analysis of Both Case Studies Based on Performance Dimension</td>
<td>81</td>
</tr>
<tr>
<td>6.3.1</td>
<td>Coordination and integration</td>
<td>81</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>6.3.2</td>
<td>Information sharing</td>
<td>82</td>
</tr>
<tr>
<td>6.3.3</td>
<td>Cost</td>
<td>84</td>
</tr>
<tr>
<td>7</td>
<td>CONCLUSION, LIMITATIONS AND FUTURE RESEARCH</td>
<td>85</td>
</tr>
<tr>
<td>7.1</td>
<td>Implications of the study</td>
<td>85</td>
</tr>
<tr>
<td>7.2</td>
<td>Limitations</td>
<td>86</td>
</tr>
<tr>
<td>7.3</td>
<td>Future research</td>
<td>87</td>
</tr>
<tr>
<td>8</td>
<td>REFERENCES</td>
<td>88</td>
</tr>
<tr>
<td>9</td>
<td>APPENDIX</td>
<td>102</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 1: Barcode---------------------------------------------------------------5
Figure 2: RFID system----------------------------------------------------------6
Figure 3: Sample 96-bit EPC-----------------------------------------------------7
Figure 4: Structure of RFID tag -----------------------------------------------9
Figure 5: Classification of RFID tags ------------------------------------------9
Figure 6: Active tag and reader communication --------------------------------9
Figure 7: Passive tag and reader communication ---------------------------------10
Figure 8: Inductive vs deductive --------------------------------------------38
Figure 9: Illustrate database selection ----------------------------------------42
Figure 10: Metro Group RFID implementation timeline --------------------------60
Figure 11: Metro Group saving--------------------------------------------------69
Figure 12: Metro Group growth on sales ----------------------------------------70
Figure 13: Metro Group net sales ----------------------------------------------70
Figure 14: Wal-Mart RFID implementation timeline -----------------------------77
Figure 15: Wal-Mart net sales -------------------------------------------------80
Figure 16: Wal-Mart net income ------------------------------------------------80
LIST OF TABLES

Table 1: ISO RFID tag standards .................................................................................. 8
Table 2: Passive vs. active tags ..................................................................................... 11
Table 3: Operating frequencies and performance characteristics .................................. 13
Table 4: Type of database .............................................................................................. 41
Table 5: Collected data related to SC literature ............................................................. 44
Table 6: Collected data related to IT/IS literature ......................................................... 45
Table 7: Collected data related to General business management literature .................. 45
Table 8: Collected data related to Conference papers .................................................. 46
Table 9: Empirical evidence of RFID in the retail sector .............................................. 52
Table 10: Empirical evidence of RFID in the warehouse and distribution centres .......... 52
Table 11: Empirical evidence of RFID in manufacturing .............................................. 53
Table 12: Empirical evidence of RFID in forward SC’s ................................................. 53
Table 13: Empirical evidence of RFID in Closed-Loop SC’s ......................................... 54
CHAPTER ONE

1 INTRODUCTION

1.1. Research Background

In the last few years, we have witnessed major changes and developments in information technology (IT) that have changed our way of life and improved the capabilities of organisations across a wide range of business models and services. In some cases, this has led to businesses acquiring, interpreting, retaining and distributing vast quantities of information, thereby allowing them to succeed and even dominate their industries (Angeles 2005, p. 51).

With the use of real-time, live, streaming data-gathering technologies and decision support system (DSS), organisations have successfully implemented radio frequency identification (RFID) technologies as integral parts of their supply-chain (SC) systems to create and capture monetary benefit as well as save valuable time and resources (Wu & Subramaniam 2009, p. 1). With the continued growth of RFID technology, the organisational capabilities seem to grow, benefitting from economies of scale, allowing them to capitalise on key market opportunities and increase their ability to obtain accurate data about a current entity’s properties and location (Wu & Subramaniam 2009, p. 2).

RFID technology has been hailed as a very innovative and beneficial technology which has imparted tremendous value to business organisations over the last couple of decades (Chao at el. 2007, p. 268). This technology has been analysed carefully and has been greatly improved to ensure that it is compatible with modern supply chain management systems which was expected to result in global sales exceeding $7 billion by 2008 (Chao et al. 2007, p. 268). Organisations worldwide have begun to notice the time, resources and costs that are saved by the adoption of this technology into their SC processes and therefore more and more businesses are beginning to take interest in this technology. This in turn, has led to an increase in the demand for experts in the field of RFID systems who can tailor the system for a particular task or organisation, thereby conferring an advantage over their competitors (Chao et al. 2007, pp. 268–69).

RFID is hailed by most industry experts and technology pundits as ‘one of the most exciting technologies for SCM’ (Wu & Subramaniam 2009, p. 1), but it is the sub-field of retail that has seen, and continues to show, the most potential for growth
for the application of this technology. RFID provides accurate, up-to-date, practical information about products, such as their identification data, pricing, and dates of manufacture and expiration, and with the use of geo-navigational instruments, it allows producers to pinpoint and track their products and quickly calculate the current inventories on hand (Ilie-Zudor et al. 2011, pp. 232–33). As noted previously, introducing RFID technology into a business enhances and increases speed, accuracy, detailing, and visibility of operational information updates of specific units of business production. Implementing this technology in the business leads to shorter production cycles, reduced overall labour costs, improved delivery and more reliable customer service (Bose & Pal 2005, p. 102).

The purpose of this research is to describe the impact of RFID technology on specific retail businesses in the world, in particular, focusing on the retail SC performance. This will be done by providing case studies of real-life retail businesses currently facing increasing competitive intensity. Due to rising expenditures and increasing cost of utilities, retailers are forced to reduce costs and implement new IT solutions in order to compete effectively in the industry.

During the past three decades there has been much transformation in the retail industry. Geuens et al. (2003, pp. 241–42) pointed out that due to the emergence of many store alternatives such as supermarkets, hypermarkets and discount stores, traditional cornerstones have been developed or eliminated. Like other sectors, retail industries are influenced by factors such as globalisation, heavy competition, cost inflation and the increased demands of customers. Kärkkäinen (2003, p. 529) pointed out that taking care of the grocery products with a short shelf-life, stringent traceability needs and the necessity to monitor temperature, are some of the challenges faced by the retail industry. Management of increasing numbers of stock-keeping units (SKUs) is also one of the challenges in this industry.

For example, in the 1960s, the number of SKUs in a grocery store was found to be 6000. Today the number has become 40,000. Due to this increase, there has been an increase in the rate of daily sales. So, Abernathy et al. (2000, p. 176) pointed out that the collection of sales transactions data by manual means has become an outdated procedure. Fleisch and Tellkamp (2005, p. 384) pointed out that there would be an increase in the transaction costs and inventory incorrectness, if manual means were used to collect sales transaction data. For example, Procter and Gamble spends around $35 to $75 to go through the transaction of each customer. Moreover,
these methods will require manual work at various levels such as in taking the order, data entry, data processing, invoicing and forwarding (Kärkkäinen & Holmstrom 2002, pp. 242–43).

RFID applications as well as the EPC network are found to offer more benefits to the retail sector. Moreover, RFID applications (Srivastava 2004, pp. 64–65) and the EPC network (Srivastava 2004, p. 67) are highly preferred by well-known retailers such as Wal-Mart.

Procter and Gamble identified that the installation of an RFID system would reduce annual expenses by $400 million (Smith 2005, pp. 18–19). Gaukler and Seifert (2007, p. 35) stated that records management, logistics and transport, assembly and manufacturing, tracking of assets, locating the objects and environment sensors are mainly discussed in recent studies on the role of RFID in SCs.

While analysing the effects of RFID on SCM, most researchers focused on the possible advantages, inventory inaccuracy issues, the bull-whip effect and replenishment plans. One of the frequently reviewed methodologies is simulation study. In order to analyse the effects of RFID and information sharing on SC performance Zelbst et al. (2010, pp. 582–83) developed a model. In order to standardise the inventory cost, an Inspection Adjusted Base-Stock (IABS) approach for inventory replenishment was developed by Kok and Shang (2007, p. 186). According to them an important value of perfect inventory information could be achieved with the help of this approach. The researcher of this study has been motivated by the aforementioned research findings. The assessment of effects on the fulfilment of customers’ expectations and reduced total inventory cost in RFID-enabled SC has been the focus of this research.

1.2. Research Objectives

The aim of this research is to arrive at a comprehensive solution in identifying the impact of RFID technology in improving the SC’s performance in retail industry. From previous studies it has been observed that records management, logistics and transport, assembly and manufacturing, tracking of assets, locating the objects and environment sensors are mainly discussed in the recent studies of the role of RFID in SCs. The overall impact of RFID application on retail SCs in improving their performance is the crux of this research. This research focuses on RFID technology and its implementation at two retail chains in the United States (US) and Europe.
where this technology has been successfully implemented and provides answers to the research questions. The research questions addressed are:

Q1. How is supply chain performance measured in the retail industry?
Q2. Can RFID technology improve the performance of a retail supply chain?
Q3. How do Metro and Wal-Mart compare on the supply chain performance dimensions?

Two case studies were reviewed in order to answer the research questions. One case study is about the biggest retailer in the world, the US-based Wal-Mart. The other case study relates to the third-biggest retailer in the world, the European retailer Metro Group.

1.3. Thesis Structure

The first chapter of this research presented a summary of the research background and the main objectives of the research. The second chapter of this research summarises the technology background, including the different Auto-ID technologies such as Barcode and RFID and provides a comparison between the technologies. The third chapter of the research presents a review of the SC performance literature, summarising the findings from the review in order to provide answers to the research questions. The fourth chapter of the research outlines the research methodology adopted, including the research design, the philosophy, strategy and approach to the research, the data collection methods adopted and the identification of possible resources. The fifth chapter of this research presents the RFID technology and its impact on the SC performance literature review. The sixth chapter of this thesis discusses real examples of retailers’ implementations of RFID in the US (Wal-Mart) and Europe (Metro Group). The end of this chapter presents the analysis of both case studies based on specific performance dimensions. The seventh chapter of this research concludes the contributions of the research. The research limitations are discussed and future research directions are proposed.
CHAPTER TWO

2 TECHNOLOGY BACKGROUND

Auto-ID Technology is a wide term given to a host of technologies that are used to help machines identify objects/items. Auto-ID is often coupled with automatic data capture. That is, companies want to identify different items, capture much information about them and in some way enter the data into a computer without having employees type it in. Auto-ID technologies include many different types of technologies such as Barcode, smart cards, RFID, optical character recognition (OCR) and Biometrics such as (fingerprint procedure and voice recognition). The main Auto-ID technology in the research area of this thesis is RFID technology, though the thesis presents some details about Barcode and makes comparisons between both technologies.

2.1 Barcode Technology

Barcode is one of the common Auto-ID technologies. It is consists of a label with alternating black and white lines as exemplified in Figure 1, often representing a Universal Product Code (UPC) that can be read by an optical scanner (Boeck & Wamba 2008, p. 440). It is used to improve the accuracy of information and data transmission speed (Manthou & Vlachopoulou 2001, pp. 157–158) and to encourage information sharing. Manufacturers and retailers in a SC have traditionally used barcoding as a means to track and keep control of the products in a logistic system. For more details about the advantages and disadvantages of the Barcode technology see Appendix A1 (p. 102).

2.2 Radio Frequency Identification Technology (RFID)

Instead of using the product code in the form of bars to encode the data, RFID assigns a Radio Frequency (RF) to every item, and this acts as the item’s identity (Wu & Subramaniam 2009, pp. 1–2). The most important difference between RFID and other past technologies, such as Barcode, is the possibility of identifying items without line of sight (Curtin et al. 2007, p. 88), simultaneous reading of several tags achieved by the use of anti-collision mechanisms and the ability to identify items
uniquely using the EPC concept. Because RFID systems can be run without the need for human interaction, the scanning process can be fully automated (Karmakar 2010, p. 13). An RFID system was composed of a transponder and a reader linked to a computer system as shown in Figure 2 (Ton et al. 2009, p. 2).

![Figure 2: RFID system (Karmakar 2010, p. 14)](image)

A typical RFID transponder, the RFID tag itself, consisted of a microchip with an attached radio antenna; the chip stored information about a product or shipment (Chang 2011, p. 275). The information stored in the tag was detected and recorded when a tag passed near a reader equipped with an antenna that tracked the tag’s movement in real time and passed its digital identity to a computer system (Ton et al. 2009, p. 2). Readers could be incorporated into almost any component of the SC, from the manufacturing floor to the sales floor. In retail stores, for example, readers could be integrated into receiving and shipping gates and into ‘smart shelves’ that could sense individual items (Ton et al. 2009, p. 2). For more details about the RFID history see Appendix A2 (p. 103).

In order to fully understand RFID technology, it is very important to understand the major components that make up the technology and the frequencies that make its transmission possible throughout the process from tagging to reading and so on. The following part of this section presents the most important standards that are currently in use.

### 2.2.1 Standards

There are two types of RFID standards used in the world today. The first is the EPC Standard, a subsidiary of GSI (which created the UPC barcode that has been used for decades), which manages the EPC. The second is the ISO standard, which is a standard managed by the International Organisation for Standardisation (ISO) (Bhuptani & Moradpour 2005, p. 72).

#### 2.2.1.1 EPCglobal

EPCglobal is an organisation that is funded by large corporations with an interest in developing an international RFID standard to create better SC operations.
The EPC is used to identify an item in the SC and hold data that identifies the producer, the object class and the serial number of the item (Rochel & Joyce 2006, p. 226). In addition, EPC is a numbering scheme that allows assignment of a unique identifier to any physical object. It can be regarded as the next generation UPC, which is used on most products today. EPC enables the assignment of a unique identifier to each item, also allowing every item to be uniquely identified. The recent format of the EPC type is shown in Figure 3 (Al Kattan & Al-Khudairi 2009, p.194). The data that allows this unique identification includes the following fields:

- **Header**: Identifies the EPC’s version number.
- **Manager Number**: Identifies the enterprise using the EPC number.
- **Object Class**: Refers to the class or category of product, similar to SKU.
- **Serial Number**: Identifies a unique instance of the item being tagged.

![Figure 3: Sample 96-bit EPC](Al Kattan & Al-Khudairi 2009, p. 194)

EPCglobal classifies the EPC tags into five class types. For more detailed description about the five class types of EPC tags see the table in Appendix A3 (p. 104). The EPC standard is generally adopted, especially in the commercial sector. The U.S. Department of Defence (DOD) and Wal-Mart are both using the EPC standard class 1 (Wisner et al. 2009).

### 2.2.1.2 ISO

ISO is a network of the national standards institutes of 148 countries, based on only one representative per country, organized and coordinated by its headquarters in Geneva, Switzerland. Although ISO is a non-government organisation, it focuses on creating standards and building universal consensus for the acceptance of those standards. Since its inception in 1947, ISO has published more than 13,000 international standards for many different industries (Bhuptani & Moradpour 2005,
ISO has developed many standards for RFID use with the ISO 18000 standard being specifically for SC use (Rochel & Joyce 2006, pp. 226–227). The ISO 18000 parts 1 through 6 address the parameters for Air Interfaces Communication for globally accepted frequencies see Table (1) which provides more detail about the six parts of the ISO standard.

<table>
<thead>
<tr>
<th>ISO Standards</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 18000</td>
<td>Generic Parameters for Air Interface Communication for Globally Accepted Frequencies.</td>
</tr>
<tr>
<td>ISO 18000-1</td>
<td>Parameters for Air Interface Communications below 135KHz. It is the ISO standard for LF.</td>
</tr>
<tr>
<td>ISO 18000-2</td>
<td>Parameters for Air Interface Communications at 13.56 MHz. It is the ISO standard for HF and it has Read/Write (R/W) capabilities.</td>
</tr>
<tr>
<td>ISO 18000-3</td>
<td>Parameters for Air Interface Communications at 2.45GHz. It is the ISO standard for MF. It also has R/W capabilities.</td>
</tr>
<tr>
<td>ISO 18000-4</td>
<td>Parameters for Air Interface Communications at 5.8GHz.</td>
</tr>
<tr>
<td>ISO 18000-5</td>
<td>Parameters for Air Interface Communications at 860 – 930 MHz. It is the ISO standard for UHF. It also has R/W capabilities.</td>
</tr>
<tr>
<td>ISO 18000-6</td>
<td>Parameters for Air Interface Communications at 433.92 MHz. This is the Manifest tag for the US DOD.</td>
</tr>
</tbody>
</table>

Table 1: ISO RFID tag standards
(Bhuptani & Moradpour 2005, pp. 72–73)

ISO 18046 focuses on RFID tag and interrogator performance test methods, whereas ISO 18047 covers RFID device conformance test methods. This standard is similar to the EPCglobal standard. (Bhuptani & Moradpour 2005, p.73).

2.2.2 The major RFID components

In general the RFID system consists of four important hardware components which are responsible for identifying and capturing data. The major components are: tag, reader, antenna and computer (Backend system) (Ton et al. 2009, pp. 2–3).

2.2.2.1 Tag (Transponder)

Tags are similar to barcodes, and are attached to the item/case and store the single ID of the item/case (Karmakar 2010, p. 16). The most common tags mainly consist of two important elements, the Integrated Circuit (IC) chip and the antenna (Ton et al. 2009, p. 2). In some cases, depending on specific business processes, they have sensors for measurement of values such as temperature and humidity (Zelbst & Sower 2012, p. 15). The tag antenna communicates with the reader through electromagnetic waves (Ngai & Gunasekaran 2009, p. 1). Also in semi-active and passive tags, antennas search for the power from the interrogator to operate the onboard IC chip of the tag. The IC stores the single ID of the item/case in the form of numbers (Karmakar 2010, p. 16). Figure 4 illustrates the structure of RFID tags.
There is a large and growing concentration on RFID systems from many commercial and government agencies, such as huge retail chains like Wal-Mart and the Metro Group, government agencies such as the U.S. DOD, as well as agriculture agencies such as the National Livestock Information System (NLIS) in Australia (Preradovic et al. 2008, p. 92). A wide range of RFID tags has been developed to meet the special needs of all potential users. This thesis presents only RFID tags that are based on power supply classification as shown in Figure 5.

- **Power supply classification**

  The most important classification of RFID tags is based on their power supply requirements. RFID tags are generally classified based on their modes of power supplies and can be defined into three major types (Hassan & Chatterjee 2006, p. 4).

  1- **Active tag**

  The first type of RFID tag based on power supply is the active tag. This type has an onboard power supply in the form of a battery (Kasiri et al. 2012, p. 256). Active tags use battery power to provide the necessary power for the operation of the tag over a period of time (Ton et al. 2009, p. 3). Consequently, active tags do not need to use the RF carrier signal’s energy to energise the data processing section and hence have a longer reading range (Banks et al. 2007a, p. 10) as shown in Figure 6.
Active tags have the capacity to store and process more data than passive tags and this is due to the on-board power supply, which is less sensitive to the strength of the reader’s interrogation signal (Kasiri et al. 2012, p. 256). For more details on how an active tag communicates with the system see Appendix A4 (p. 105).

2- **Semi-active tag**

The second type of RFID tag that is based on power supply is the semi-active tag. The most significant difference between active and semi-active tag is that semi-active tag has the provision of an on-board power supply for minor signal processing tasks, but this power is not utilised for amplification of received and transmitted signals. Therefore a semi-active tag consumes much less power from the on-board battery and has a longer life in comparison to the active tag (Banks et al. 2007a, p. 10). However, due to this budgeted power allocation, which is only for the signal-processing unit, the reading range of semi-active tags is much less than active tags. As a result, a semi-active tag is an in-between approach compared to a fully active tag and a battery-less fully passive tag (Banks et al. 2007a, p. 10). For more details on how a semi-active tag communicates with the system see Appendix A4 (p. 105).

3- **Passive tag**

The third type of RFID tag that is based on power supply is the passive tag. This type of tag does not have a power supply and therefore relies only on the power emitted from the reader for both data processing and transmission (Kasiri et al. 2012, p. 256) see Figure 7.

![Figure 7: Illustration of passive tag and reader communication](image)

Passive tags consist of three kinds of circuits, namely an antenna, a rectifier and a Manchester encoder (RFID chip) (Na et al. 2004, p. 547). This means that some passive tags lead to data processing, but others do not. These tags are usually in the form of Electronic Article Surveillance (EAS) transponders generally found in retail shops for security purposes. Many passive tags have low-power consumption and low costs due to the nature of their design, because they rely solely on the reader’s emitted energy to select their operating energy (Banks et al. 2007a, pp. 8-9). For more details about the passive tag see Appendix A4 (pp. 105–106).
Table 2 shows the comparison between active tags and passive tags based upon some important characteristics:

<table>
<thead>
<tr>
<th></th>
<th>Passive tags</th>
<th>Active tags</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power</strong></td>
<td>Not self-powered (derive power from the electromagnetic field generated by the reader); require higher powered readers.</td>
<td>Battery powered (internal); can be effective with less powerful readers.</td>
</tr>
<tr>
<td><strong>Read range</strong></td>
<td>Typically under 3m</td>
<td>Can be 30m or more</td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td>Lower data transmission rates; subject to noise; greater orientation sensitivity; fewer tags can be read simultaneously; no self-reporting capability.</td>
<td>Higher data transmission rates; better noise immunity; less orientation sensitivity; more tags can be read simultaneously; self-reporting capability.</td>
</tr>
<tr>
<td><strong>Read/write capability</strong></td>
<td>Mostly read-only; may also WORM (write once read many) or EEPROM (electrically erasable programmable read-only memory).</td>
<td>Read many, write/rewrite.</td>
</tr>
<tr>
<td><strong>Tag cost</strong></td>
<td>Less than $1 a piece</td>
<td>As much as $20 a piece or more.</td>
</tr>
<tr>
<td><strong>Physical size</strong></td>
<td>Can be as small as a dust particle; less weight due to no internal battery.</td>
<td>Larger than passive, may be as large as a brick; greater weight due to internal battery.</td>
</tr>
<tr>
<td><strong>Life</strong></td>
<td>Long operational life (no electrical expiration).</td>
<td>Limited due to battery life (up to 10 years).</td>
</tr>
<tr>
<td><strong>General application</strong></td>
<td>Suitable for tracking low value consumer goods; supply chain tracking.</td>
<td>Suitable for tracking high value items over long ranges; security/personnel access control; asset tracking.</td>
</tr>
</tbody>
</table>

Table 2: Passive vs. active tags (Tajima 2007, p. 264)

2.2.2.2 Reader (Interrogator)

The second component of the RFID system is the reader (Chang 2011, p. 275). Readers are RF transmitters and receivers controlled by a microprocessor or digital signal processor that communicates with the tags (Banks et al. 2007a, p. 11). Readers use an attached antenna, which captures data from tags and then pass the data to a computer for processing (Kärkkäinen 2003, p. 530). In passive systems, readers transmit an energy field that ‘wakes up’ the tag and provides the power for the tag to operate. In active systems, a battery in the tag is used to improve the effective operating range of the tag. Readers can have an effective range of a few centimetres to a few metres based on the frequency of operation and the type of tag. Readers come in many different types and sizes and offer many different features. They can be affixed in a stationary position, or integrated into a mobile computer that is used for scanning barcodes (Attaran 2007, pp. 250–251).

2.2.2.3 Antenna

The third major component of the RFID system is the antenna. An RFID antenna emits radio waves from the reader’s transmitter and accepts RF replies from the tags (Banks et al. 2007a, p. 11). According to Bhuptani and Moradpour (2005, p. 47) there are two basic types of antennas. The first type is the linear antenna, which
transmits an RF in vertical or horizontal straight lines and allows for long-distance reading. However, these types of antennas emit an RF in a narrow band; hence tag orientation is critical for effective reading. The second type is the circular antenna, which emits an RF in circular patterns, thus tolerating multiple tag orientations and supporting more general RFID purposes. Reading distances for circular antennas might be shorter than linear antennas, however, the ranges are wider.

2.2.2.4 Computer (Backend system)

The fourth component of the RFID system is the backend system. This component is in general a computer positioned close to the readers. This system has two main functions. The first function is to receive data from the readers and to perform data processing tasks such as filtering and collation. The second function is as a device monitor, making sure the reader is functioning properly, securely and with up-to-date instructions. The computers are connected to readers through networking technologies such as Transmission Control Protocol (TCP) and Internet Protocol (IP), or sometimes through serial connectivity (Attaran 2007, p. 251).

2.2.3 Frequencies

Based on Lin (2009, p. 833), RFID tags today use four types of frequencies to transmit data to the reader, these types are as follows:

2.2.3.1 Low Frequency (LF)

In the early days of RFID, LF tags were the most common. The LF tags operate between 125 kHz and 134.2 kHz. Because of the electromagnetic properties of LF frequencies those tags can be read while attached to objects containing water, animal tissues, metal, wood and liquids. They are only suitable for proximity applications, because they can only be interrogated from a very short range of a few centimetres. They have the lowest data transfer rate among all the frequencies and usually store a small amount of data.

2.2.3.2 High Frequency (HF)

The HF tags operate at 13.56 MHz. Their operating principles are similar to LF tags and they use near-field inductive coupling as a source of power to communicate with the interrogator. HF tags have a better reading range than LF tags -and larger
memory size (up to 4 Kbyte) than LF tags. For more details about HF see Appendix A5 (p. 107).

2.2.3.3 Ultra-High Frequency (UHF)

In the UHF band, 433 MHz and 860- to 960-MHz are used for UHF RFID applications. The 433-MHz is used for active tags, while the 860- to 960-MHz band is used mostly for passive tags. In contrast to LF and HF tags, UHF tags and interrogators use far-field coupling or backscatter coupling to communicate with one another. Therefore, UHF tags have a reading range of up to 20 metres in good conditions. UHF tags offer more memory size and a better reading range. For more details about UHF see Appendix A5 (p. 107).

2.2.3.4 Microwave Frequency (MF)

The MF tags operate at 2.45-GHz. The 2.45-GHz is used for both types of tags (active and passive). The benefit of an MF system is a high data rate that can enable wireless communication between devices at a very high speed. MF is also used in real-time location systems. MF tags cannot be easily read while attached to objects containing water, tissues, metal, wood and liquids. In particular, MF tags have been intensively used for electronic toll collection and railroad monitoring.

Table (3) summarises key RFID operating frequencies and performance characteristics (Tajima 2007, p. 263).

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>LF 125–134.2 KHz</th>
<th>HF 13.56MHz</th>
<th>UHF 433MHz and 860–930MHz</th>
<th>MF 2.45GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tag type</td>
<td>Passive</td>
<td>Mainly passive</td>
<td>Active and passive</td>
<td>Active and passive</td>
</tr>
<tr>
<td>Read range</td>
<td>&lt;0.5m</td>
<td>1.0m</td>
<td>20m</td>
<td>10m</td>
</tr>
<tr>
<td>Tag size</td>
<td>Larger</td>
<td>Different size</td>
<td>Smaller</td>
<td>Smaller</td>
</tr>
<tr>
<td>Data storage</td>
<td>Smaller</td>
<td>Up to 4Kbyte</td>
<td>Larger</td>
<td>Larger</td>
</tr>
<tr>
<td>Data transfer rate</td>
<td>Slow</td>
<td>Medium</td>
<td>Fast</td>
<td>Fastest</td>
</tr>
<tr>
<td>Ability to read near metal or wet surface</td>
<td>Best</td>
<td>Better</td>
<td>Worse</td>
<td>Worst</td>
</tr>
<tr>
<td>Tag cost</td>
<td>High</td>
<td>Lower than LF tags</td>
<td>Lowest</td>
<td>High</td>
</tr>
</tbody>
</table>

Table 3: Operating frequencies and performance characteristics
2.2.4 Current issues facing RFID technology

The current and the most significant issues facing the RFID technology are as follows (Ngai & Gunasekaran 2009, pp. 3–5):

- Security and privacy
- Quality assurance
- Cost challenges

For more discussion about the current issues facing RFID technologies see Appendix A6 (pp. 108–109)

2.3 Comparison of RFID and Barcode

In some ways, RFID is similar to the Barcode; both technologies use labels and scanners to read labels, and both rely on an IT system that cross-references the ID on the label and relates it to an object or a class of objects using a database system. However, there are several advantages of RFID over the Barcode:

- Unlike barcodes, data is not gathered manually, and since companies have a great number of products, using RFID leads to a drastic reduction in workload.
- When using a Barcode, the operator has to scan the items one by one, while the RFID reader can automatically receive information from the tags.
- RFID scanning can be done at greater distances than by Barcode scanning.
- The constraints that apply to the positioning of the tags are much weaker than the constraints when Barcodes are concerned. Tagged objects can be read in different orientations at high speeds. Orientation sensitivity depends on antenna design.
- Tags can store more data than Barcode.
- RFID readers can communicate with multiple tags. As a consequence, it is possible to capture the information concerning an entire shipment (Dolgui & Proth 2008, pp. 4464–4465). For more details about the comparison of RFID and the Barcode see Appendix A7 (p. 110).
CHAPTER THREE

3  SUPPLY CHAIN PERFORMANCE LITERATURE REVIEW

In order to answer the aforementioned research questions, this part of the thesis reviews the previous and existing literature that examines SCM and the measurement of SC performance. The importance of the literature review to the researcher has been strongly identified by Altinay and Paraskevas (2008, p. 8) as follows: ‘Research that builds on past research benefits from an already existing baseline for exploration and in most cases extends and improves our understanding of a phenomenon’. Hart (2001) examined the definition and made modifications suggesting that it is essential to conduct research studies with respect to the current subject as it promotes the development of new insights and predicts from an overall collection of various views, facts and opinions from other people in these areas.

The findings from the review are summarised in the ensuing pages. These have been divided into three sub-sections. The first sheds light on the findings concerning SCM including its different definitions. The second talks about what is meant by SC performance, its dimensions and the measurement of SC performance, also giving a summary about the SC performance evaluation models. The last sub-section provides an analysis of the framework.

3.1 Supply Chain Management

According to Vidal and Goetschalckx (1997, p. 8), each and every aspect of the SC process encompasses its own terminology and deals with various issues and methods which are often studied separately without considering the other stages. An SC can also be termed as a value stream (Jones 1995, p. 194), an extended enterprise (Greis & Kasarda 1997, p. 55), a keiretsu (Lamming 2000, p. 758), a value chain (Evans and Berman 2001, p. 135), and a pipeline (Lambert & Cooper 2000).

These terms may produce different meanings and diverge in their manner dependent upon the type of entity involved and managed. All these SC approaches are observed to be common with respect to a focus on the external environment of an organisation. Further, SCM can be defined in operational terms in relation to the flow of product (Matta & Feger 2012, p.4731), in terms of management process (Johnston 1995, p. 214) and in terms of management philosophy (Mentzer et al. 2001, p. 1). Sometimes it has been observed that different authors have used different terminologies for SCM in the same document itself (Mentzer et al. 2001, p. 1). As a
result, the lack of uniformity in the concept of SCM creates more complication in research, teaching and managerial advancement in the field (Mentzer et al. 2001, p. 2).

SCM has been defined by New and Payne (1995, p. 61) in its traditional approach. They identify it as the chain encompassing several organisational boundaries which connect the product and supply process of each element from raw material to the end user. In terms of this definition, SCM covers the total value chain and connects each of these elements of products and supply management from the extraction of raw material to delivery to its end user.

A definition of SCM which is concerned with various stakeholders has been identified by Croom et al. (2000, p. 68), being based on the concept of creating value for all actors in the SC, even which different stakeholder used different performance evaluation systems which cannot be possibly reconciled. A service SCM framework has been defined by Matta and Feger (2012, p. 4733) as the management of information, processes, service performance, capacity as well as funds from the first supplier to the final customer.

Based on a strategic perspective, Gunasekaran et al. (2004) defined SC metrics as involving tactical, strategic, operational and generic measures. However the task still remains for the manager to identify the appropriate measure for the application in precise settings. Also, Johnston (1995, pp. 214–215) has defined SCM based on strategic perspective as the process of strategically managing the movement and storage of materials, parts and finished inventory from suppliers, through the firm to end users.

SC comprises some principal components as discussed by Robinson and Malhotra (2005, pp. 318–320), the most valuable for this study being strategic management and performance components. Some of the strategies used with SCM are: (1) Competitive strategy, (2) Product development strategy, (3) Marketing and sales strategy, (4) SC strategy, (5) Strategic fit, (6) Global freight management strategy, and (7) Customer focus strategy and Strategic sourcing.

From an environmental perspective, Leenders et al. (2006) identified the importance of SCM in which the SC was found to consider the relations between the business, its customers and its providers.

In terms of this definition, the management of raw supplies and services from supplier to manufacturer, from service provider to the customer and back with
progression in social as well as economic impact that can be explicitly considered in Sustainable Supply Chain Management (SSCM). An effective definition of collaborative SCM has been given by Ketchen and Hult (2007, p. 574) which identifies the chain as one which offers a significant and largely available resource for the potential advantage of many companies. According to the authors, a wide range of performance outcomes can be influenced by SC activities including profits on investment, growth, market share, return on assets and so on.

Based on Mehrjerdi (2009, p. 131) SCM involves the strategic, visible integration as well as achievement in terms of the social, environmental and economic aspirations of the organisation involving a systemic coordination of key inter-organisational business processes for enhancing the performance of the individual company as well as its SC, for long-term progress.

The mixture of value-chain, customer value and market orientation research provides a new idea about SCM. By early 2000, the concept of SCM and marketing had been widely recognised and a number of definitions focused on SCM on the basis of marketing perspective (Jüttner et al. 2007, pp. 378–379). Following this there is reallocated to Supply Chain Orientation (SCO) which is the dominant approach in most research (Jap 1999, p. 465; Bowersox et al. 2000).

Mentzer et al. (2001, p. 2) defined SCO as the process by which there is recognition of the different systemic, strategic implications which are the resultant of an effective management of the different processes involved in management of the SC. The SCO is the process whereby the SCM can be led by an overarching philosophy intended for the creation of a strategic, systemic, fully synchronised, well-orchestrated and tightly-integrated supply and demand management perspective.

In order to solve this confusion, a generic analysis of SCM has been presented by Mentzer et al. (2001, pp. 3–4) through examining various definitions of the terms ‘Supply Chain’ and ‘Supply Chain Management’ and expressed in the following manner:

- Supply Chain is as follows:
  ‘Set of three or more entities directly involved in the upstream and downstream flow of products, services, finances, and information from a source to the customer’.
Supply Chain Management is as follows:
‘The systematic, strategic coordination of the traditional business functions and tactics across these business functions within a particular company and across businesses within the SC, for the purpose of improving long-term performance of the individual companies and the SC as a whole’.

3.2 Supply Chain Performance

In order to achieve a competitive advantage, SC’s need to be managed appropriately (Deshpande 2012, p. 2). The management of materials, products, and information flows through the SC has a direct impact on the success of organisation strategies and the performance of these organisations (Chan et al. 2002, p. 117). According to Hyvönen (2007, p. 343) reported that the business strategic orientation, information systems strategic alignment and information systems effectiveness have positive impacts on performance. Harrison and New (2002, p. 263) reported the results of a major international survey undertaken in 1999 into the relationships between corporate strategies, SC strategy and SC performance across the most important industrialised countries. The survey founded that 90% of the respondents believed that SC performance was very important and also the main significant key for achieving competitive advantage (Forslund 2007, p. 915).

According to Akyuz and Erkan (2010, p. 5137), the major challenge faced by researchers in SC is the analysis of the SC system’s performance. The analysis of SC performance is complex because of the differences in the entities involved, such as suppliers, manufacturers, wholesalers, and customers. For the purpose of this research, SC performance is defined as the multiple measures of performance developed by the organisation to measure the ability of an SC to meet an organisation’s long-term and short-term objectives (Deshpande 2012, p. 2).

Chen et al. (2000, p. 436) argue that exogenous variables such as demand and lead time variability, SCM and planning decisions and SC design decisions also have an impact on SC performance.

Beamon (1999, p. 275) contends that the SC performance measures describe the cost and customer responsiveness. Relevant cost may refer to inventory and operating costs such as manufacturing and distribution costs, while the stock-out or backlog occurrence and probability of occurrence such as lead time, stock-out probability and fill rate, are associated with customer responsiveness (Vachon &
Klassen 2008, p. 299). The definition of the policies are given importance, as are concerns by the SCM and planning decisions for organising the material and information flow throughout the network at strategic, operational and tactical levels. For instance, the definition of lot-sizing policies and forecasting methods need be considered (Cigolini et al. 2004, p. 7).

3.2.1 Measuring the performance of supply chain

A set of activities that are commenced by an organisation for promoting effective management of its SC is known as SCM practices. Donlon (1996, p. 54) argues that the latest and advanced version of the SCM practices includes activities such as supplier partnership, outsourcing, cycle time compression, continuous process flow and IT sharing. In order to address and describe the SCM practices in the empirical study, factors such as purchasing, quality and customer relations are used by Tan et al. (1998, p. 2). Factors such as the core capability of inter-organisational system implementation such as Electronic Data Interchange (EDI) and the avoidance of excess inventory levels by delaying customisation at the end of the SC, are also included in the study evaluating SCM conducted by Kotzab and Alvarado (2001, p. 183).

According to Tan et al. (1998, pp. 2–3) there are six aspects with respect to SCM practice when evaluating by means of factor analysis: (1) SC integration; (2) information sharing; (3) SC characteristics; (4) customer service management; (5) geographical proximity; and (6) Just-in-time (JIT) capability.

In order to measure and address the buyer-relationship, Chen and Paulraj (2004, p. 119) make use of factors such as supplier base reduction, long-term relationship, communication, cross-functional teams and supplier involvement. According to Min and Mentzer (2004, p. 63) the SCM practice also involves activities such as accepted objectives and goals, information sharing, risk and award sharing, cooperation, process integration, long-term relationships and SC leadership. The literature describes SCM practices from different perspectives and considers having a common objective for promoting organisational performance. By examining and evaluating the literature, it is observed that SCM practices can be measured in terms of five distinct dimensions: strategic supplier partnership, customer relationship, information sharing level, information sharing quality and postponement.
Furthermore, the literature also discusses aspects such as geographical proximity, JIT or lean capability, cross functional teams and logistic integration (Chen & Paulraj 2004, pp. 119–120), and agreed vision and goals and SC leadership (Min & Mentzer 2004, pp. 64–65). Despite their interest, these aspects are not considered as primary concerns for the study given survey length and the nature of the measurement instrument.

3.2.2 Intricate performance measures in a supply chain

Most of the metrics that are implemented in the SC performance evaluation are formulated to address the operational performance, evaluate improved effectiveness and investigate the strategic alignment of the entire SCM (Beamon 1999, pp. 277–279). In order to capture the construct of performance measurement, all the different dimensions of SC performance need to be considered simultaneously (Deshpande 2012, pp. 5–7). Furthermore, there is the issue of which dimensions of SCM are distinctly related to SC performance. There are four classifications of SC performance measures, summarised as follows:

1. **Quality**: Refers to the relative reliability of chain activities (Beamon 1999, p. 280), identifying quality as one of the significant dimension of SC performance. It also identifies that the most significant factors influencing the quality of the SC are: availability of materials, data standards, high volume of transactions, integrity of the SC, quality of information and the exchange and process variation.

2. **Time**: (referred to as cycle time) is the time duration from initiation to completion of the supply process. Deshpande 2012 (pp. 2–4) recognized time as an important dimension of SC performance, as it involves both the delivery time and the order placement time. This dimension is operational in terms of the ability of the SC to respond to changes in customer demand and meet timely orders.

3. **Cost**: Efforts to manage cost involve enhancing value by either reducing expenses or increasing customer benefits for the same cost level. Melnyk et al. 2010 (p. 33) consider cost as one of the most important dimensions of SC performance. In today’s competitive business environment, customers need reliable on-time delivery from their suppliers. In the short term, delivery deviations – the earliness and lateness from the targeted delivery date – must be analysed, as both early and late deliveries are disruptive to an SC’s performance. Early and late deliveries introduce waste in the form of excess cost into the SC; early deliveries contribute to excess inventory
holding costs, while late deliveries may contribute to production stoppages costs and loss of goodwill. It is becoming more common for customers to penalise their suppliers for early as well as late deliveries.

4. **Flexibility**: Refers to an SC’s responsiveness to changes in customers’ needs. Angerhofer & Angelides (2006, pp. 283–284) identify flexibility as one of the most important dimensions of SC performance. The measurement of SC delivery flexibility is essential to estimate the responsiveness of SC. Delivery flexibility deals with delivering products, which are desired by the customer, to the market as quickly as possible. The greater the flexibility, the better is the responsiveness of the SC. For instance, if the SC is highly flexible, it would continually meet the changing needs of customers and help customers to view the SC favourably (Gunasekaran et al. 2001, pp. 72–73). The construct of delivery flexibility is operational in terms of the ability of the SC to change or deliver orders according to fluctuations in demand by customers (Kumar et al. 2006, p. 306).

Another important dimension of SC performance is information sharing. Li et al. (2005, pp. 618–619) identified information sharing as one of the dimensions that influence inter-organisational SC performance. An efficient SC performance requires a significant degree of information sharing (Yao & Dresner 2008, p. 362) and advances in IT enable information availability (Cantor & Macdonald 2009, p. 220). This facilitates communication, coordination, and collaboration among SC partners through information sharing (Fawcett et al. 2009, p. 223). The economic aspects of information sharing have long been studied and, moreover, it is generally believed that an increase in useful information results in generating positive value (Zhou et al. 2009, pp. 572–573). Information sharing in the SC encompasses demand, product and inventory information sharing (Hall & Saygin 2012, p. 398). According to Li et al. (2005, p. 620) information sharing is an important element that reflects cooperation in SC performance. As well, Simatupang and Sridharan (2002, p. 17) state that information sharing is ‘the ability to see private data in a partner’s systems and monitor the progress of products as they pass through each process in the SC’. Stevenson and Spring (2007, p. 687) have stated that accurate and real-time information flow in the SC is considered as important as material flow by most organisations.

An analysis comparing customer demand and inventory information sharing versus no information sharing between a retailer and supplier finds that there is a
significant improvement in SC performance when sharing customer demand and inventory information versus no information sharing (Hall & Saygin 2012, pp. 397–398). Operational and inventory costs are shown to be lower, when production schedule and customer demand information are shared compared to no information sharing (Hall & Saygin 2012, pp. 397–398). A study using four modes of information sharing, the first without information sharing, the second with partial information sharing, the third with one-way full information sharing, and the last with two-way full information sharing, concludes that information sharing increases performance with the adoption of each new mode (Tu et al. 2003, p. 1750). According to Zhou and Benton (2007, p. 49) information sharing leads to an increase in information flow through the SC which significantly contributes in reducing SC costs, improving partner relationships, increasing material flow, enabling faster delivery, and also helping to improve the order fulfilment rate as a result. This contributes to customer satisfaction (Li & Lin 2006, p. 43), enhances channel coordination (Sahin & Robinson 2005, p. 580) and facilitates the achievement of competitive advantage (Chandra et al. 2007, p. 2508). Based on Li and Lin (2006, pp. 45–47), many researchers agree that information sharing is a key driver of an effective and efficient SC by speeding up the information flow, shortening the response time to customer needs, providing enhanced coordination and collaboration and sharing the risks as well as the benefits.

Furthermore, Li and Wang (2007, p. 1) considered integration and coordination of SC to be of strategic as well as operational importance. The past decade has been characterised by a move away from independent operation strategies towards integrated SC strategies based on improved coordination with both suppliers and customers (Lambert & Cooper 2000, p. 66). Li and Wang (2007, pp. 2–3) indicated that improvements in many SC performances appeared to be more positive in companies that integrated with both suppliers and customers than in companies that integrated exclusively with suppliers or exclusively with customers. Droge et al. (2004, p. 57) found significant relationships between ‘external integration’ incorporating both suppliers and customers, and performance. These studies indicated that coordination involving both suppliers and customers has positive effects on performance. Cagliano et al. (2006, pp. 85–88) state that many studies confirm that the higher the level of integration the higher the operational and business performance of a firm. A survey by Frohlich and Westbrook (2001, p. 186)
showed that firms with higher levels of supplier and customer integration also demonstrated the highest SC performance. Bagchi et al. (2005, pp. 77–78) state that in most SCM literature the more integration between the different parts of the system, the better the performance of the SC. The main belief is that SC integration is a useful approach to improve different measures of SC performance (Ou et al. 2010, p. 28).

Olugu and Wong (2009, p. 202) describe SC performance measurement as the feedback on operations which are geared towards customer satisfaction and strategic decisions and objectives. They also pointed out that SC performance measurement reflects the need for development in operational areas which are found wanting in performance measures. Neely (2005, p. 1265) described the measurement of performance as the process of quantifying the efficiency and effectiveness of actions. Gunasekaran et al. (2004, p. 334) identified effective performance measurement as necessary in SCM. Olugu and Wong (2009, p. 203) asserted that lack of adequate performance measurement has been identified as one of the major obstacles to efficient SCM. It is an established fact that in order to improve SC effectiveness and realise a smooth flow of resources within it, there is a need to measure its performance. Najmi and Makui (2011, pp. 2–3) state that measuring the SC performance can facilitate a better understanding of the SC, positively influencing SC players’ behaviour and improving its overall performance. Trkman et al. (2010, p. 320) states that the higher levels of SCM practice, such as the highest standard and quality of information sharing, could lead to enhanced competitive advantage and improved performance. Cai et al. (2009, p. 514), state that monitoring and improving the performance of SC has become an increasingly complex task and involves many management processes, such as identifying measures, defining targets, planning, communications, monitoring, reporting, and feedback. Akyuz and Erkan (2010, p. 5138) mention the following points as the purposes of a performance-measurement system: (1) identifying success; (2) identifying if customer needs are met; (3) better understanding of processes; (4) identifying bottlenecks, waste problems, and improvement opportunities; (5) providing factual decisions; (6) enabling progress; (7) tracking progress; and (8) facilitating more open and transparent communication and cooperation.

Beamon (1998, p. 281) identified three types of performance measures as necessary components for an SC performance-measurement system: resources,
output, and flexibility. The author also noted that since each of these measures is vital for the success of the overall performance of the SC, and the outcome of each affects the others, SC performance-measurement systems must measure each of these three types of measure. Agarwal et al. (2006, p. 213) employed a framework that uses the sensitivity of the market, process of integration, information driver, and flexibility to measure the performance of the SC. Within this framework, they explored the relationship between lead time, cost, and quality and service levels with the leanness and agility of an SC in the fast-moving consumer goods business. Lead time, cost, and levels of quality and service are key determinants in the proposed framework. Soni and Kodali (2010, pp. 45–46) used facilities such as transportation, information, inventory, sourcing and pricing categories of measurement that are proposed by Chopra and Meindl (2004).

The SC performance is also classified as quality and quantity, cost and non-cost, strategic, operational or tactical focus and SC processes (Gunasekaran et al. 2004, pp. 334–335). The systematic determination and identification of the appropriate metrics are observed to have complexity as the majority of the measurement systems had an inadequate strategy alignment and balanced approach thinking (Beamon 1999, p. 281). SC performance is addressed by means of implementing a Balanced Scorecard (BSC) and Activity Based Costing (ABC) for overcoming the issues and challenges (Liberatore & Miller 1998, p. 132).

There are also certain other research studies that have balanced frameworks such as performance measurement matrix, results determinants framework, performance pyramid and other like factors (Neely 2005, p. 1266). Based on the process perspective the Supply Chain Operations Reference (SCOR) model was established for promoting and developing a systematic SC performance measurement and improvement tool. The model is observed as a systematic approach for determining, evaluating, and monitoring SC performance as argued by Neely (2005, p. 1267). Balanced performance measurement system at multiple levels that addresses five cores SC processes, such as plan, source, make, deliver and returns, are developed and included in the SCOR model (Neely 2005, p. 1267).

There are certain limitations observed with respect to the measurement models, such as the extended BSC and SCOR models, for evaluating SC performance. There are many individual measures observed with respect to the SC framework. In their study, Shepherd and Günter (2006, pp. 248–251) concluded that there were 39 cost
related factors, 22 time related factors, 35 quality related factors, 28 flexibility related factors and 8 innovation related factors with respect to a single SC performance. Regardless of the information provided by these models for activities such as decision making, selecting and trading off, there are many measures that achieve effective and critical improvement strategies which are complex for various SC participants. These models do not provide any information related to a cause–effect relation among various hierarchical and individual Key Performance Indicators (KPIs).

The existing models are determined as inadequate while considering quantitative analysis of complicated interviewed relationships regardless of providing information related to cause and effect relations among goal oriented KPIs (Tse et al. 1999, pp. 72–73). According to BSC and SCOR models, a KPI is observed as uncoupled model. The models are able to business operations effectively and act as a good communication tool, at the same time the models are observed to have influence on the overall performance of the firm by implementing KPIs.

### 3.2.3 Competitive priorities of the supply chain

Defining the competitive priorities of the firm is determined as the fundamental concept of the operation strategy. The basic priorities such as cost, quality, delivery and flexibility are included in the factor (Ward et al. 1998, p. 1035) and the additional aspect of innovation is also included (Krause et al. 2001, p. 498). A company while allocating limited resources is recommended to make a trade-off among these priorities (Skinner 1969, p. 137) and consider the trade-off with respect to improvement rates of different priorities (Kroes & Ghosh 2010, p. 126).

Boyer and Lewis (2002, p. 10) determined from analysing 110 manufacturing plants that there exist trade-offs between cost and flexibility, delivery and quality, delivery and flexibility. The trade-off is also determined in the differentiation between lean and agile manufacturing (Inman et al. 2011, p. 345) and SC strategies (Qi et al. 2011, p. 372). The same is also determined with the efficiency responsiveness dichotomy in SC priorities and efficient SC focus for the cost efficient fulfilment of predictable demand and responsive SC for immediate response to unpredictable demands (Parmigiani et al. 2011, pp. 212–213).
3.2.4 Supply chain fit: Implications for service management

According to Alexander and Randolph (1985, p. 845) firms are likely to reach enhanced performance together with strategic, structural and contextual variables, environmental and internal reliability or fit. There is also a long history of studying internal fit and environmental fit in the operations management literature (Boyer et al. 2000, p. 603). For instance, Skinner (1969, p. 137) promotes the configuration of a firm’s strategy in association with its functional development.

According to product process matrix research, a firm’s processes are supposed to be fit with the characteristics of its products (Hayes & Wheelwright 1979, p. 135). As noted by Ward et al. (1996, p. 602) the ‘manufacturing strategy, competitive strategy, environment, and structure are configured or interlinked such that there are natural congruence’s between these elements’. Ward et al (1996, p. 623) hypothesised that ‘business units which conform to one of the configurations will be more likely to perform well than those which are not aligned’. Together with an SC strategy context, the SC fit can be formalised on the basis of the framework of Fisher (1997, pp. 106–107) who formalises fit through characterising the SC as being either efficient or responsive and products as being either certain or predictable.

An SC fit can be defined in our research as the flawless strategic reliability among product supply, demand characteristics including life-cycle length, product variety, demand predictability, lead-times, service and specific market requirements and supply design characteristics such as product design strategy, inventory strategy as well as supplier selection factors. The perfect consistency for uncertain or unpredictable products can be attained through an efficient SC (Fisher 1997, p. 105).

3.3 Supply Chain Performance Evaluation Models

Various SC performance evaluation models are discussed in this section with respect to their key features and previous existing literatures that evaluates the importance of SC performance measures.

3.3.1 Characterisation of different supply chain performance evaluation models

There are certain specific corpuses of aspect that summarise and conclude various studies that are conducted for examining the performance evaluation model as implemented in the corporate background (Hsu & Li 2011, p. 138). During the 1990s, determining the performance evaluation systems for the organisation was observed to be a key and important practice. The major objective of the performance
evaluation systems is to develop and formulate the measurement systems that can be adopted and implemented in the corporate strategy (Neely et al. 1995, pp. 80–81). There are a number of types of measurement systems among which the BSC (Kaplan & Norton 1996, p. 55) and the European Foundation for Quality Management (EFQM) excellence model (EFQM 2010) are observed to be renowned and effective systems. The systems address and examine the autonomous factors such as firms, subsidiaries, business units and other such factors while excluding the complexity with respect to value created chains (Kumar et al. 2012, p. 278). There are numerous measurement systems for analysing SCs with respect to such aspects as collaboration, human resource management and sustainability, as discussed by Gunasekaran et al. (2004, p. 336).

In this study the researcher discusses the most important SC performance evaluation models as following:

3.3.1.1 Balanced Score Card (BSC)

Kaplan and Norton (1996) developed the model in 1990 for supporting the organisational strategy in balanced measures. The model was developed based on four analytical dimensions: customers, finance, internal processes and innovative growth. For measuring performance, the model also makes use of human dimensions. The frame structure for BSC with respect to SCM is observed to be similar to that of the BSC formulated for corporate management, and as developed by Kaplan and Norton. Determining SC metrics, Gunasekaran et al. (2001, pp. 73–74) formulated an SCM performance evaluation model. It is vital to examine and understand the related factors of SCM with respect to organisation activities and proposed objectives and goals of the firm before formulating the balanced SCM scorecard. It is necessary to ensure that the metrics that are included in the SCM score card should address the proposed criteria.

3.3.1.2 Supply Chain Operation Reference Model (SCOR)

The Supply Chain Council (SCC) developed and formulated the model in 1996. Meyer et al. (2002, p. 102) argues that the model is a reference model that includes standardised terminology and processes. There are three aspects that are included in the model of SCOR:

1. Modelling tool that makes use of standardised processes as building blocks;
2. Certain KPIs;
3. Benchmarking tool for comparing KPIs among other companies.

The SC of the firm is also influenced and promoted by the SCOR model. The model is reframed and developed by the SCC, so that all industrial and service sector firms can adapt to the model for implementing the decisions that are made with respect to the organisation’s strategic plan. The model is based on benchmarking and makes recommendations for level one metrics. There are also certain disadvantages of the model, as it is observed to be manufacturing-centric, including such metrics as source, make, deliver and return, which are not especially important for process control (Bolstorff 2003, p. 6) and an overreliance on benchmarking that provides innovation.

3.3.1.3 Global Supply Chain Forum (GSCF)

In 1994, Ohio State University developed the model and was discussed by Cooper et al. (1997, p. 4). Three organisation levels are depicted, namely the strategic, tactical and operational, is encompassing an association between SC process and structure. As well, the GSCF defines SCM as ‘the integration of key business processes from end user through to the original suppliers that provide products, services and information that add value for customers and as well stakeholders’ (Lambert 2005, p. 28). The implementation of this model is carried out through three elements: the SC network structure, the business processes and the management components. The model considers and gives importance to such aspects as (Lambert 2005, p. 28):

- **Customer Relationship Management:**
  Provide the structure for how the relationship with customers is developed and maintained.

- **Customer Service Management:**
  Provide the key point of contact for administering product and service agreements.

- **Demand Management:**
  Provide the structure for balancing the customer requirements with SC capabilities, including reducing demand variability and increasing SC flexibility.

- **Order Fulfilment:**
  Includes all activities that are necessary to define customer requirements, design the logistics network and fill customer orders.
• Manufacturing Flow Management:
Includes all activities that are necessary to obtain, implement and manage manufacturing flexibility and move product through the plants in the SC.
• Supplier Relationship Management:
Provide the structure for how the relationship with suppliers is developed and maintained.
• Product Development and Commercialisation:
Provide the structure for developing and bringing to market new products jointly with customers and suppliers.
• Returns Development:
Includes all activities related to returns, reverse logistics, gate-keeping and avoidance.

The eight key business processes that are mentioned above run along the SC and cut across firms and functional silos within each firm.

3.3.1.4 Strategic Audit Supply Chain (SASC)

In 1999 the model was developed and discussed by Gilmour (1999, p. 358). The SC is evaluated by the model with respect to the factors of processes, IT and organisation at an organisational level. The model classifies the logistic chain into the following six factors: (1) customer orientation; (2) distribution; (3) sales planning; (4) lean production; (5) supplier partnership; and (6) integrated management of the chain. The model also relates to the capabilities of the IT and organisation of the chain.

3.3.1.5 Global EVALOG (Global MMOG/LE)

Odette International Limited and the Automobile Industry Action Group developed the model in 1999 and it was examined in the study by Odette (2010). Partner site processes and performance are evaluated by the model and also incorporates a continuous improvement approach. Along with the automobile industry, the model is determined to be applicable for metalwork and chemical industries as well. The model is developed with respect to six stages as follows: strategy and improvement, work organisation, production planning, customer interface, process control and supplier interface.
3.3.1.6 AFNOR FD X50–605

The model was developed in 2008 and examined in the study by AFNOR (2010). The model provides a common framework for strategic reflection and describes distinct logistics processes. The model also describes the performance levers that are associated with each process. The model can be implemented for six functional aspects, namely, determining needs and setting of objectives, logistic system design and development, production, sales and distribution, logistic support and control over international logistic process.

3.3.1.7 Efficient Customer Response (ECR)

In 1994, an ECR Association of manufacturers and retailers developed the model and it was examined in the study by ECR (2010). The model is determined to be important for the present study. Effective inter-organisational practices are evaluated in the model by implementing the maturity-based evaluation tool of global mapping. The cooperation and association between industrialist and distributors in the consumer goods sector is described and evaluated in the model. It develops a common language that relies on joint performance evaluation by actors and drivers in the chain. The model is designed based on 45 aspects that are classified into four sections as follows: consumer demand management, SCM, technological platforms and integration.

3.3.1.8 Strategic Profit Model (SPM)

The model was formulated in 2002 with respect to the DuPont model as discussed in the study by Stapleton et al. (2002, p. 92). The model depicts the association between strategic and operation levels with the help of financial ratios. The model recommends the strategic and financial implementation with respect to cost drivers with the support of returns on asset or net value measurements.

In this section the researcher has presented an analysis of SC performance by presenting different models evaluating the importance of SC performance measures. The major objective of the performance evaluation systems is to develop and formulate the measurement systems that can be adopted and implemented as part of the corporate strategy. In this context the foregoing section has presented many different models, including BSC, SCOR Model, GSCF, SASC, Global EVALOG, AFNOR FD X50-605, ECR and SPM. The study focuses on evaluating the
performance of the service industry, particularly the retail industry. Hence it is essential to ensure that the performance of the SC measures adopted in the industry is accorded the importance they deserve.

### 3.3.2 Application of SC tool of service industry and retail sector

There is only limited literature available for analysing SSCPMS, particularly considering the evaluation of system design and performance measures. Some researchers describe an inadequacy with respect to understanding the service chain measures linking the objectives and motivation of different entities of the service SC.

For addressing the reliability and validity problems resulting from the implementation of SCM in service, the Q-sort technique was adopted for the scale development process by Boonitt and Pongpanarat (2011, pp. 219-220). Their model makes use of meaningful scale for measuring service SCM processes. Four management processes such demand management, capacity and resource management, order process management and service performance management, are observed to have limited qualifying scales and recommends an examination of the scales.

The application of SCM models with respect to the management of service SCs are observed and examined in the aforementioned studies (Ellram et al. 2007, p. 45). There are also certain other researchers who have concerns about defining traditional SC operation in terms of services (Ellram et al. 2004, p. 18). The relation between the service providers and end consumers of the services are also evaluated in various studies (Sampson 2000, p. 352).

Arlbjørn et al. (2011, pp.279-281) discuss the recommendation that SCM distinguishes the task with respect to various aspects. Various types of relations between customers and suppliers also influence the differentiation practices. Ellram et al. (2004, p.20) argue that there are seven theoretical processes of service SCs, namely: Information flow, capacity and skills management, demand management, customer relationship management, supplier relationship management service delivery management, and cash flow. The importance of after sales service in the SC is envisaged and predicted in the study by Gaiardelli et al. (2006, p. 150). Financial performance measures are considered at the strategic level and customer satisfaction, flexibility and productivity are observed and examined at the operational level.
The existing business practice highlights and encompasses the importance of the SCM and highlights that there is an increase in the service expenditure. Practitioners and academicians are determined to face challenges and complexity with respect to efficiency and effectiveness of service SCs. The organisations in retail industry are able to attain and promote their competitive advantage in the developing international economy by means of publishing information related to performance measurement SC practices using effective channels. Definitions, performance measures and metrics of service SC performance measurements are detailed in the study based on the literature review. Hence the implementation of effective service SC performance measurement in the retail industry is considered an effective tool for facing and overcoming the challenges and issues.

3.4 Framework Analysis

3.4.1 Cost

It is essential to identify what is to be used in measuring the SC cost. The measures that have been applied with respect to SC cost were described by Hoole (2005, pp. 3–4). As most of the companies have started to outsource, it becomes necessary to perceive an SC view of cost. In considering cost, cases with and without RFID, were compared by Kok et al. (2008, pp. 510–512). In this study, the break-even prices can be calculated with the development of an analytical framework. The implementation of RFID ensures that the organisation breaks-even, by recovering the cost of implementation. This is closely associated with reduction in the loss of items in inventory, reduction in value of lost items and the reduction in cost of man-hours.

In the main processes of the Fast Moving Consumer Goods (FMCG) SC, the impact of RFID technology and EPC system was quantitatively assessed by Bottani and Rizzi (2008, p. 551). Consequently, the implementation of RFID and EPC did not reveal any significant benefits for all echelons examined. In order to analyse the costs and benefits of RFID investment, it is necessary to combine a multi-criteria tool for the valuation of qualitative factors with a Monte–Carlo simulation of anticipated financial factors (Doerr et al. 2006, p. 726).

The SC cost has been defined by Manuel (2006) as the cost factors of labour, lost sales, inventory holding as well as theft costs. Here the order cost has also been taken as a cost factor in this study; increased automation could improve the operation efficiency along with reducing the labour cost. An increasing level of accuracy,
visibility, and security could reduce the gap between physical and system inventory (Manuel 2006). This in turn increases the availability of products. As a result, the average inventory level along with labour cost, inventory holding and lost sales are found to have decreased, apart from the order cost. That aside, due to increased security, theft costs have decreased.

In general, the satisfaction of the customer and the expected sales revenue can be enhanced by RFID but this factor is not considered in this study. The impact of RFID on the SC can be evidently identified by defining the accuracy of the relationship among the factors linked with quantitative parameters thus the benefits can be measured (Ustundag & Tanyas 2009, p. 31).

### 3.4.2 Quality management

In order to be sure about the quality control, it is necessary to use RFID technologies at the time of production. Twist (2005) pointed out that Defects in Polartec fleece fabric were found by Malden Mills by means of RFID technologies when compared to Nestlè which insisted its staff do regular cleaning so as to manufacture products at a high quality. However it was found that the adoption of the RFID technology by Polartec fleece fabric resulted in lower quality when compared to Nestle which relied solely on employee vigilance. This is attributed to an on-going problem for RFID in the form of erratic performance. Wyld (2006, p. 155) pointed out that a few pilot studies were found to have 20% to 50% faulty tags and false readings and this percentage error cannot be tolerated.

With the emergence of more tags and readers, it becomes necessary to address problems such as reader collision (the possibility of the clash of signals from numerous readers), tag collision (confusions due to the number of tags), and the intervention of other wireless devices (e.g. mobile phones). According to Li and Visich (2006, p. 410), it is also necessary to address the system-related issues such as complications in system integrations with the available applications and the high susceptibility of RFID applications to computer viruses. Raman et al. (2001, p. 137) observed that 65% of the inventory records from thirty seven retail stores had inaccurate data. As the RFID technologies could reduce the human errors in material handling, they would be helpful in improving the accuracy of inventory records. Lapide (2004, p. 17) pointed out that the accuracy of consignment data could be
improved by means of RFID technologies. As a result, demand forecasting as well as production planning could also be improved.

In the past, incomplete or untimely data was used while taking management decisions. Lin et al. (2006, pp. 23–24) pointed out that nowadays, the quality of management decisions has been enhanced with the help of accurate data. Moreover, business data, such as product catalogues and information about the suppliers can be reviewed, checked and compiled with the help of RFID technologies.

3.4.3 Time

It is vital to ensure that timing of material tracking, process delivery and inventory management is effectively managed so that there are no delays in the process. The following aspects have been identified.

RFID technologies could enhance material tracking by means of the manufacturing process. This in turn will be useful to maintain a continuous link between production and supply availability. Kärkkäinen and Holmström (2002, p. 245) stated that with RFID technologies, Toyota has automated its goods receipts. As a result, the figure of costly production disruptions has been reduced. As stated by Lu et al. (2006, p. 75), equipment downtime as well as maintenance expenses can also be reduced with the help of RFID technologies.

In the field of exception management, it is necessary to respond to unexpected situations before they develop into key issues. But this is not easy. McFarlane and Sheffi (2003, pp. 3–4) pointed out that the data can be acquired in timely fashion and the material and information flows can also be synchronised with the RFID technologies. As a result, these technologies could speed up exception management.

With available RFID technologies, it becomes easier to identify the delivery-related issues and do service adjustments on the basis of available data (McCrea 2005, p. 59). Lapide (2004, p. 19) pointed out that a few examples of exception management including invoice settlement, delivery data adjustment, and sending of alerts, could also be automated with the help of RFID technologies.

3.4.4 Information sharing

Customer value can be increased and the expenses of the SC can be reduced by means of information sharing. This in turn will provide competitive advantages to the firms. The chain members who provide products with high quality can sell them at
higher prices and improve their trade. There are many examples to show the positive influence of information sharing on SC performance. Simatupang and Sridharan (2002, p. 18) pointed out that sales and stocking data have been shared by Wal-Mart, a retailing firm, with its main dealers. This online sharing of information was found to improve its SC performance.

Products and SC data can be shared among the trading firms by means of RFID, only if the firms are collaborative in nature. Rutner et al. (2004, p. 36) stated that with the help of RFID technologies, the firms can automate their electronic bills. As a result of this automation manual tracking of paper trails will be greatly reduced. Murphy-Hoye et al. (2005, p. 18) pointed out that RFID technologies have an extreme access to comprehensive SC information. In this context, they could customise the aggregation or disaggregation level of SC information so as to provide flexible information sharing.

The challenges in this process should be understood by the firms so as to overcome the issues. A huge amount of data will be collected and saved by the RFID systems, so the firms have to keep this data safe at all levels. This is one of the major challenges. The flow of key business information across the SC will be allowed with the flawless integration of business processes. The important processes of SC partners such as WMS and ERP have also been influenced by these systems. The quantity of data flowing across the EPC global Network and high stocks in some centres develops the major risk. It is possible to carry out corporate espionage by means of tracking or information gathering. Business process reengineering is the major prerequisite for the implementation of RFID technologies. These reengineering processes are found to have in-built security risks

3.4.5 Flexibility

Flexibility in the process of SCM using RFID is identified to be associated with inventory management, material handling and space utilisation. The use of RFID could assist in reducing stock-outs as well as lost sales by increasing the accuracy of finished goods inventories. Availability of poor products in U.S. will cost the retail industry up to $30 billion per year (Teresko 2003, p. 60). Due to reduction of stock-outs by using RFID, the retailers are able to focus on promoting tracking and execution, price differentiation strategy, category management, new product introduction, and shelf layout (Rutner et al. 2004, p. 36).
Schell (2004) pointed that RIFD could diminish the safety stock by enhancing the inventory data along with the reduction of stock-outs. Using smart shelf, it could further reduce inventory through on time delivery, vendor managed inventory as well as automatic replenishment (Småros & Holmström, 2000, p. 57).

Twist (2005, p. 236) stated that as 50% to 80% of the cost of labour is found to be associated with material handling, reduced material handling could significantly influence the warehousing operation by providing better flexibility. Apart from this, other benefits for the warehousing operation includes shorter delivery lead times, automated routing for cross-docking, fewer shipping delays and earlier customs clearance for cross-border deliveries (McCrea 2006, p. 49).

The use of RFID will improve the efficacy as well as the flexibility of space utilisation so as to better handle the material. As new efficiencies are afforded by RFID, a new port intended by Napoleon Gate Entry Management System was only one-third the size of the old terminal port (Twist 2005). By reducing product incompatibility problems, RIFD could provide the flexibility of space for allocation of hazardous products, as well as allocate space for scanning the barcode.

The framework analysis identifies the impact of RFID on different attributes of an organisation. For example from the study it is observed that the average inventory level along with labour cost, inventory holding and lost sales are found to decrease, resulting in reduced cost. As the RFID technologies could reduce the human errors in material handling, they would be helpful in improving the accuracy of inventory records as observed in terms of quality management. From this section it is also observed that time management is a very important aspect which influences the tracking of material, processing of delivery and inventory management. The use of RFID technology enhances the accuracy and speed of response. The flow of key business information across the SC will ensue along with the flawless integration of business processes thereby improving information and flexibility management. The important processes of SC partners like WMS, ERP and TMS have also been influenced by these systems.
CHAPTER FOUR

4 RESEARCH METHODOLOGY

The purpose of this chapter is to present the methodology of the research adopted in order to arrive at an answer to the proposed research questions:-

Q1. How is supply chain performance measured in the retail industry?
Q2. Can RFID technology improve the performance of the retail supply chain?
Q3. How do Metro and Wal-Mart compare on the supply chain performance dimensions?

This chapter presents the research design, the philosophy, strategy and approach to the research, the type of data collection method adopted and the identification of possible resources.

4.1 Research Process

The research questions which are presented in this study have been developed from a survey of existing literature. In order to arrive at solutions to the research questions, it is important to present a justification for the type of methodology adopted. In this study, to arrive at a specific methodology, the researcher has made use of the Saunders et al. (2009, p. 108) research onion methodology. In the following sections the reasons for choosing different elements in the layers of the onion methodology are identified by relating them to the proposed research questions.

4.1.1 Research philosophy

The outermost layer of framework presented by Saunders et al. (2007, p. 101) is the research philosophy, defined as ‘Philosophies or Paradigms (that) represent what we think about the world (but cannot prove). Our actions in the world, including the actions we take as inquirers, cannot occur without reference to those paradigms’ (Lincoln & Guba 1985, p. 15). In this study, the researcher proposes to adopt a constructionist approach from an epistemological perspective. ‘Epistemology is intimately related to ontology and methodology; as ontology involves the philosophy of reality, epistemology addresses how we come to know that reality while methodology identifies the particular practices used to attain knowledge of it’ (Krauss 2005, pp. 758–759). This approach is adopted as it was found to present a
constructive outlook with respect to the nature of research and its objectives (Crotty 1998, p. 43). Despite the large number of articles which are published in relation to RFID applications in SCM these papers are found to focus on specific issues which revolve around their impact whereas this thesis attempts to examine the entire process by considering two separate case studies.

4.1.2 Research approach

The use of the research approach in the onion methodology is to identify if the theory is applied correctly and explicitly in the research (Saunders et al. 2009). In this study, the researcher has decided to follow an inductive approach as distinct to a deductive approach. In an inductive approach a ‘bottom-up’ method is adopted to construct or evaluate general propositions derived from specific empirical evidences and research outcomes, in order to achieve a consensus viewpoint. There are a number of theories and evidences which were previously available with respect to implementation of RFID technology. By adopting the inductive approach the researcher identifies a possible answer to the proposed research questions thereby proposing a new conceptual framework (Flick 2002, p. 109). The main aim in using the inductive approach in the form of secondary data collection measures is to identify whether proper measures were taken to understand the structure of the proposed research problem. A comparison of the research alternatives is clearly presented in the following Figure 8.

![Figure 8: Inductive vs. deductive approach](image)

4.1.3 Research strategy

The type of research strategy adopted is dependent on the overall quality, as well as the value it adds, to the design of the study. In the Saunders et al. (2009, p. 258) framework, it is observed that either a qualitative, quantitative or a mixed
research strategy may be adopted. A qualitative research approach is adopted when there is a large amount of non-numerical data to be analysed and common patterns or themes to be established. A quantitative approach is adopted when a large amount of numerical data is to be processed and examined (Creswell 2003, p. 221).

In this study, a combination of both approaches is used. By adopting a quantitative method, the classification of different features of the identified statistical data and various statistical models can be examined which will enable the measurement of the frequency of implementation of RFID technology in SCM (Saunders et al. 2009, p. 108). The adoption of a qualitative approach ensures that different case studies can be examined with respect to this aspect (e.g. Metro Group and Wal-Mart). A combination of these measures will help in arriving at a solution to the research questions.

This study adopts a case study approach to present an in-depth analysis of RFID adoption by two different retailers in two different scenarios (American and European). There are three types of case study approaches: the descriptive, the analytical and explanatory case studies (Hancock & Algouzzine 2006, p. 31). The case study approach explains theory and causality and:

Try to show linkages among the objects of the study. It asks why things happen the way they do. The researcher collects facts and studies the relationship of one set of facts to another, with the hope of finding some causal relationship between them. (Hancock & Algouzzine 2006, pp. 32–33).

In this study the researcher adopts an explanatory case study approach by examining the available secondary data in order to arrive at evidence supporting the impact of RFID on SC performance.

4.1.4 Data collection

This research adopts a secondary data collection approach, wherein the researcher makes use of a set of data which previously exists in order to arrive at the possible solutions to a proposed problem (Kiecolt et al. 1985, p. 87). The main difference between secondary and primary data collection approaches is the means by which data is acquired. Secondary data analysis involves the application of analytical techniques of previously synthesized and categorised data. The aim is arrive at a pattern or a conclusion which was not previously presented in the original or the primary study. Studies often contain large amounts of data which is not
discussed by the principal investigator enabling re-examination of this pre-existing data and arriving at a common theme (Kiecolt et al. 1985, p. 87).

In this study the researcher has made use of a wide range of secondary data sources as there is a large body work previously undertaken with respect to RFID, SCM and SC performance. The researcher has concentrated on both explorative and indicative studies in trying to understand the impact that the adoption of RFID technology will have on improving the performance of the SC, by comparing two different case studies (Kiecolt et al. 1985, p. 87). The adoption of secondary data analysis enables the uncovering of different aspects of a research problem which requires a great deal of elaboration in terms of revision of hypotheses, refinement of existing measures, and the proposal of new conceptual measures which can be applied (Saunders et al. 2009).

4.2 Sources of Secondary Data

The research adopts a mixed approach wherein both quantitative and qualitative data is collected from different databases. Academic peer reviewed articles were treated as of most importance. Apart from the articles presented in proceedings of conferences, white papers and working papers were also considered. The database that the researcher employed in this thesis is the University of Wollongong database and its related databases.

Initially, the process of literature review began with the computer-based sources such as databases including the following:

- **Scopus**: The largest citation and abstract database of peer-reviewed literature and scientific web sources (covers scientific, technical, medical, social sciences literature as well as arts and humanities).
- **ACM Digital Library**: A database that includes information technology, computing and related fields, such as magazine articles and conference proceedings from the Association for Computing Material (ACM).
- **IEEE Xplore**: A database specifically, for electrical and electronic engineering, including quality technical literature including IEEE transactions, journals, magazines, standards and conference proceedings.
- **Business Source Complete**: A business research database covering all aspects of business, including reports, SWOT analyses and company profiles as well as journals and e-books.
- **Harvard Business Review**: A research-based magazine that focuses primarily on management techniques.

The search terms used to mine data from these databases included the following key words: information technology, SCM, improved performance, RFID, information flow, cost, integration, coordination, time, speed and flexibility.

In order to evidence the database searches conducted, the research fields were narrowed to the main topic. Table 4 shows how many entries and results appeared on different databases and how the results were narrowed and selected. Table 4 is merely an example of the most common key words (RFID technology, SCM or improved performance) when searching the relevant topics. This table shows the major databases used in the research while indicating the initial results of the research, relevant results and finally the selected results for the research. Of course, several changes in key words gave various sources which have all been filtered through search options.

<table>
<thead>
<tr>
<th>Database</th>
<th>Key Words</th>
<th>All results</th>
<th>Relevant results</th>
<th>Selected results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scopus</td>
<td>RFID, SCM, Speed, Improved Performance, Time, Integration, Cost, Information flow, Coordination and Flexibility</td>
<td>143</td>
<td>86</td>
<td>37</td>
</tr>
<tr>
<td>ACM Digital Library</td>
<td>RFID, SCM, Speed, Improved Performance, Time, Integration, Cost, Information flow, Coordination and Flexibility</td>
<td>176</td>
<td>112</td>
<td>58</td>
</tr>
<tr>
<td>IEEE Xplore</td>
<td>RFID, SCM, Speed, Improved Performance, Time, Integration, Cost, Information flow, Coordination and Flexibility</td>
<td>198</td>
<td>149</td>
<td>56</td>
</tr>
<tr>
<td>Business Source Complete</td>
<td>RFID, SCM, Improved Performance</td>
<td>91</td>
<td>54</td>
<td>23</td>
</tr>
<tr>
<td>Harvard Business Review</td>
<td>RFID, SCM, Improved Performance</td>
<td>36</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>644</strong></td>
<td><strong>414</strong></td>
<td><strong>173</strong></td>
</tr>
</tbody>
</table>

Table 4: Type of database

From the above table, it can be seen that the initial search (all results) using the key words, produced a large number of articles. The first step followed by the researcher was to narrow the number of articles by using database tools to limit the research results by selected publication year, area of research, type of document needed such as (journal article or conference paper). For example, of the 644 articles identified, Scopus resulted in 143 articles, ACM Digital Library resulted in 176, IEEE Xplore resulted in 198, Business Source Complete resulted in 91 and Harvard Business Review resulted in 36 articles. These lists were then shortened by selecting only papers that were relevant to the research questions based on a review of their
titles and their abstracts (relevant results), and the list contracted to 414 articles. These selections were then further scrutinised by an in-depth study to analyse the content of the articles, and papers which contained the information considered suitable for citing in this research, were selected, narrowing the field to 173 articles. Figure 9 illustrates a comparison of the different databases and their filtered outcomes.

It is noteworthy that the ACM Digital Library was the most productive resource with 33% of its database being selected, whereas the Harvard business Review was least productive with only 14% of its database being selected. The other three databases each yielded a 25% selection outcome as shown in Figure 9.

4.2.1 Criteria for inclusion

Prior to the literature review on Problem Based Learning (PBL), a few criteria were determined to select the relevant data for the study:

- The nature of the study was ascertained. Thus all sources that were not of empirical or theoretical design were not analysed.
- The variables assessed in the studies must include parameters based on RFID, SCM and SC performance.

Most of the articles and papers selected for this research have been taken from journals and conferences carrying a high ranking as shown in the accompanying tables, with the ranking of these articles and papers based on the Excellence in Research for Australia (ERA) 2010 journal and conference list. Since the journals and conferences are ranked according to the quality of the information submitted it can therefore be noted that the highest ranked journals and conferences will publish.
high quality information. The emphasis here was to select the best researched articles and papers whose information has been authenticated as being the best by high ranked journals and conferences.

The selection of articles and papers from these journals and conferences was based on the relevance of their information to the research questions. First, a key word search was conducted which resulted in a list of articles and papers that contained the relevant key word. Then the researcher reviewed the abstract of these articles and papers. If, after reviewing the abstract, it was felt that the article or paper was relevant to the research questions, it was shortlisted for further in-depth study. Those that were felt not to be relevant to the research questions were discarded.

The selected articles and papers were then scrutinised in depth and the relevant information was extracted for citing in this research. The number of times the article or paper had been cited was also taken into consideration. Articles or papers, cited on numerous occasions were given preference over the lesser cited articles and papers. The following tables provide a tabular display of the academic journals and conferences with their rankings and the number of articles and papers that have been cited from these journals and conferences in this research.

The different articles and papers which were chosen to be a part of this research are categorised as follows:

- SC related literature (See Table 5)
- IT/IS related literature (See Table 6)
- General business management literature (See Table 7)
- Conference papers (See Table 8)
<table>
<thead>
<tr>
<th>No.</th>
<th>Name of the Journal</th>
<th>Ranking</th>
<th>Number of Publication Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td>2005</td>
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<tr>
<td>1-</td>
<td>Journal of Operations Management</td>
<td>A*</td>
<td>1</td>
</tr>
<tr>
<td>2-</td>
<td>Decision Sciences</td>
<td>A*</td>
<td>1</td>
</tr>
<tr>
<td>3-</td>
<td>Academy of Management Journal</td>
<td>A*</td>
<td>1</td>
</tr>
<tr>
<td>4-</td>
<td>Harvard Business Review</td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td>5-</td>
<td>California Management Review</td>
<td>A</td>
<td>2</td>
</tr>
<tr>
<td>6-</td>
<td>International Journal of Production Economics</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>7-</td>
<td>European Journal of Operational Research</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>8-</td>
<td>MIT Sloan Management Review</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>9-</td>
<td>International Journal of Operations and Production Management</td>
<td>A</td>
<td>1</td>
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<tr>
<td>10-</td>
<td>Long Range Planning</td>
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<td>11-</td>
<td>Production Planning and Control</td>
<td>A</td>
<td></td>
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<td>12-</td>
<td>Omega International Journal of Management Science</td>
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<td>13-</td>
<td>International Journal of Production Research</td>
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<td>14-</td>
<td>Journal of Business Logistics</td>
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<td>Transportation Research Part E: Logistics and Transportation Review</td>
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<td>20-</td>
<td>International Journal of Retail and Distribution Management</td>
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<td>International Journal of Productivity and Performance Management</td>
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<td>Business Horizons</td>
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<td>25-</td>
<td>Manufacturing and Service Operations Management</td>
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<td>26-</td>
<td>Management Review</td>
<td>C</td>
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<td>27-</td>
<td>International Journal of Integrated Supply Management</td>
<td>C</td>
<td>1</td>
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<tr>
<td>28-</td>
<td>International Journal of Agile Systems and Management</td>
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<td>International Journal of Benchmarking</td>
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<td>32-</td>
<td>Richard Ivey School of Business</td>
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<td>33-</td>
<td>Journal of Operational Research Society</td>
<td>Not Ranked</td>
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<td>34-</td>
<td>International Journal of Purchasing and Materials Management</td>
<td>Not Ranked</td>
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<tr>
<td>35-</td>
<td>Logistics and Transport Focus</td>
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Table 5: Collected data related to SC literature
### Table 6: Collected data related to IT/IS literature

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<th>Ranking</th>
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<td>2007</td>
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<tr>
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<td>European Journal of Information Systems</td>
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</tr>
<tr>
<td>2</td>
<td>Decision Support Systems</td>
<td>A*</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>MIS Quarterly Executive</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Journal of Engineering and Technology Management</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Journal of Computer Information Systems</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>IEEE Transactions on Industrial Informatics</td>
<td>A</td>
<td></td>
</tr>
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<td>7</td>
<td>Communications of the Association for Information Systems</td>
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<td>8</td>
<td>IEEE Pervasive Computing</td>
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<td>9</td>
<td>IEEE Transaction Microwave Theory and Technology</td>
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<td>International Journal of Technology Management</td>
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<td>11</td>
<td>Computers and Industrial Engineering</td>
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### Table 7: Collected data related to General business management literature

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of the Journal</th>
<th>Ranking</th>
<th>Number of Publication/Year</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Journal of Marketing Research</td>
<td>A*</td>
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<tr>
<td>2</td>
<td>Management Science</td>
<td>A*</td>
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</tr>
<tr>
<td>3</td>
<td>Management Accounting Research</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Journal of Business and Industrial Marketing</td>
<td>B</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Industrial Marketing Management</td>
<td>B</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Journal of Marketing and Consumer Services</td>
<td>B</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Food Science and Technology International</td>
<td>B</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Journal of Commerce</td>
<td>C</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>International Journal of Business and Management</td>
<td>C</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>Human Systems Management</td>
<td>C</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>International Journal of Management</td>
<td>C</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>International Journal of Service Industry Management</td>
<td>Not Ranked</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>International Journal of Business and Social Science</td>
<td>Not Ranked</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>African Journal of Business Management</td>
<td>Not Ranked</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>Journal of Business Forecasting Methods and Systems</td>
<td>Not Ranked</td>
<td>1</td>
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<tr>
<td>Total</td>
<td></td>
<td></td>
<td>6</td>
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</table>

45
Finally, this chapter has identified a constructionist research philosophy involving an inductive approach. A mixed research design and secondary data collection method was utilised.
CHAPTER FIVE

5 RFID AND ITS IMPACT LITERATURE REVIEW

In order to find a solution for the research questions, this part of thesis reviews the previous and existing literature that examines RFID and its impact on the SC performance. The findings from the review are summarised in the remainder of the chapter. This has been divided into two sub-sections. The first sheds light on the findings concerning RFID. The second discusses the impact of RFID on SC performance.

5.1 RFID Technology

IT has been the fundamental infrastructure of competition and cooperation for today’s enterprises, and the positive effects of IT on SC performance (Kushwaha 2012, pp. 222–223). The author pointed out that IT needs to be combined with other enterprises’ resources to improve the SC outcome (Kushwaha 2012, p. 224). According to the Mehrjerdi (2009, p. 129) IT plays a significant role at every phase of the SC by enabling companies to analyse information. Mohammadi et al. (2012, p. 934) explains that the IT is evident in all SC fields ranging from the relationship with suppliers and producers to the relationship with the customers. Hence, the application of IT is influential in the improvement of the SC. Bowersox and Daugherty (1995, pp. 75–76) explain the best way to achieve the benefits of SCM is by using IT in the construction of integrated SC information systems. Edwards et al. (2001, p. 22) found that, companies they researched exploiting technology to integrate trading partners and reshape business models, were more successful than others. Alkadi et al. (2003, p. 103) argue that the use of IS through the SC leads to increased efficiency of SCs.

Zelbst et al. (2010, p. 582) state that RFID facilitates the information-sharing infrastructure’s ability to capture real-time information across the whole SC, which allows for the SC to improve performance. Angeles (2005, pp. 53–54) argues that RFID is SC focused, rather than organisationally focused; this is due to the ability to track resources throughout the extended SC. In addition, Asif and Mandviwalla (2005, p. 394) argue that the adoption of RFID technology can enhance SC productivity. Prater et al. (2005, p. 138) mentioned that the grocery SC must change its personnel, communications, and inventory systems to increase efficiency. They agree that technology must be an integral part of how manufacturers, warehouses,
and retailers communicate between each other. Smith (2005, p. 17) reported that the RFID system could support Customer Relationship Management (CRM) and increase customer satisfaction. A CRM system with an RFID-based system would be able to track consumers’ buying behaviours and deliver products in a timely fashion.

RFID has the potential to replace all scanning activities in the SC. It can be implemented in a ‘closed-loop’ setting where it is used internally by a single company, for example, in an electronic antitheft system or user-authentication system. It can also be implemented in an ‘open-loop’ setting, where it is used to improve the efficiency of an SC. This is the case for Wal-Mart, Metro Group and other early adopting retailers (Boeck & Wamba 2007, pp. 435). RFID technology has created new opportunities for a wide range of applications in SC, such as warehouse operation, material handling and inventory monitoring (Kim et al. 2008, p. 404). In addition, McFarlane and Sheffi (2003, pp. 4-5) list some advantages of RFID systems over barcode systems in SC operations, outlined as follows:

- Speed: Many tags can be read into a computer in parallel at the same time rather than sequentially, a single tag at a time.
- The content of various conveyances (such as trailers, cases, pallets, shopping carts) can be read automatically without opening and sorting.
- Barcodes do not work well when exposed to weather elements, when dirty, or when damaged in any way that interferes with the clear line-of-sight reading.
- Location: RFID readers can provide rough location information, especially when the goods being scanned are moving relative to the reader.

RFID has the ability to become the most important technology that offers manufacturers, distributors, and retailers improved SC performance by operational efficiency with reduced inventory and OOS (Attaran 2007, p. 252). Ton et al. (2009, p. 5) reported that several surveys and company cases found the OOS rate to be approximately 6% to 10% in grocery retailing. Based on research by the Grocery Manufacturers of America (GMA) cited in Ton et al. (2009, p. 6) 25% to 30% of all grocery stock outs involved products that were at the store but not on the display shelves. Also, Goebel and Günther (2011, p. 2) found that roughly 25% of the store related stock-outs resulted from ineffective store shelving. On the other hand, a study by Zhou (2009, p. 576) examined the relationship between inventory inaccuracy and performance in a retail SC, showing that increasing inventory accuracy can reduce
SC cost as well as OOS level. Furthermore, Szmerekovsky et al. (2010, p. 1) state that, reducing OOS, labour costs and inventory inaccuracies have all been reported by many researchers as benefits of RFID tags at the item level. In addition, extensive research has shown that pallet/case-level RFID tags reduce OOS and improves inventory accuracy, which significantly improving SCM (Hardgrave et al. 2008, pp. 188–189). Gaukler (2011, p. 362) has demonstrated that item-level RFID technology can help improve the accuracy of both store orders, as well as the backroom-to-shelf process, which are two of the main causes of OOS events.

In terms of SCM, information is the key for better performance (Erickson and Kelly 2007, pp. 36–37). RFID is an emerging technology used in SCM in recent years, particularly in the US and Europe. It has emerged as a new form of inter-organisational system (IOS) is being used to improve operational efficiency in the SC. Because of its ability to be used in real-time identification and tracking across long distances, some believe that RFID systems will fundamentally change the way companies do business (Smith & Konsynski 2003, p. 302). RFID is revolutionising the way products and goods are tracked in the SC. It can identify, classify or categorise and can manage the flow of goods and information throughout an SC (Ngai et al. 2007, p. 63). Karkkainen (2003, pp.530–531) discusses the potential in utilising RFID technology for increasing efficiency in the SC. The world’s largest retailers increasingly require their suppliers to be RFID compliant. We are seeing an increased level of interest by companies in this technology (Prater et al. 2005, p. 140).

5.2. Empirical Evidence of RFID’s Impact

Visich et al (2009, p. 1296) used the process oriented framework of Mooney et al. (1996) to classify the empirical evidence of RFID according to its operational and managerial business value. RFID can increase sales, improve retail promotion coordination, reconciliation, the effectiveness of decision making, quality and facilitate better use of resources and production control.

Visich et al. (2009, pp. 1292–1295) conducted an investigation of real benefits generated by the RFID system to SC performance through practical evidence. In the study, RFID in the SC is divided into three key areas: overview of RFID, practical studies, and analysis. The study shows that the effects of automation by introducing RFID on operational processes include reduced cost, improved shipping and
receiving efficiency, improved inventory control, reduced inventory cost and time reduction in productivity, and one of the most important automation effects is in the area of inventory control. According to Kasiri et al. (2012, p. 259) by 2008 Gillette and Wal-Mart measured how much sales had improved through better promotion execution. They monitored the promotional items in distribution centres, the back-store and promotional displays to provide the items on time and avoid OOS, achieving a 19% increase in sales.

- In the apparel industry, RFID-enabled mirrors have been used to improve the shopping experience and to increase sales. An upscale Hong Kong fashion label and retailer had a sales increase of 30% at two stores using an RFID-enabled mirror in the dressing room. The system reads the garment and visually recommends mixed and matches items, providing the customer with more choices and the retailer with more sales opportunities (Swedberg 2007a, p. 2).

- A Proctor and Gamble pilot study for the new Fusion razor achieved 92% product availability by day three of the launch, whereas the industry average is only 60% to 80% (Collins 2006b, p. 1).

- One of the most important special effects of automation is in the area of inventory control, where the use of RFID can lead to a complete elimination of manual shelf inspections by triggering automatic shelf replenishment based on recorded product movement, which then reduces stock-outs. Reducing inventory and OOS merchandise were two objectives of Wal-Mart’s RFID initiative (Visich et al. 2009, p. 1298).

- An analysis of OOS conducted by Corsten and Gruen (2003, pp.605–606) found that the average OOS rate in 40 cases was 8.3% and that 75% of the responsibility rested at the store level.

- In addition, the US Marines implemented RFID for their SC to Iraq. The impact was a reduction in average delivery times from 28 to 16 days, reduction in supply backlog from 92,000 shipments to 11,000 shipments and reduction in total inventory value in the SC from $127 million to $70 million (Collins 2006b, p. 1).

- Marks and Spencer implemented a pilot study that replaced barcodes with RFID tags when they had to replace non-standard containers with European-sized containers. The reported benefits included an 83% reduction in real time for each tagged dolly and a 15% reduction in shrinkage (Wilding & Delgado 2004b, p. 32).
‘Shrinkage’ is the financial loss attributable to a combination of employee theft, shoplifting, administrative error and vendor fraud (Wu & Subramaniam 2009, p. 2).

- A six-month research study by Hardgrave et al. (2008, p.187) of 4554 items in 24 Wal-Mart stores found that stock-outs were reduced by 26% at the 12 RFID-enabled stores. Stratification of the items by sales rate showed reductions of 20% to 36% for those items with a sales rate of 0.1 to 7 units a day and 62% for items with a sales rate of 7 to 15 units per day. There was no impact on items with a sales rate of greater than 15 units a day, but 90% of the items in the study had a sales rate of three or less per day. However, during the course of this study, stock-outs also declined at the control stores, with the net effect being a 21% reduction in the test stores compared to the control stores.

The research thesis summarised and segmented the empirical evidence of implementing RFID through different sectors:

- Empirical evidence of RFID in the retail sector;
- Empirical evidence of RFID in logistics providers;
- Empirical evidence of RFID in manufacturing;
- Empirical evidence of RFID in the whole SC.

5.2.1 Empirical evidence of RFID in retail sector

According to Rekik et al. (2008, p. 265) reducing inventory and OOS were the two important objectives of Wal-Mart’s RFID initiative. Wal-Mart CEO, Lee Scott, said: ‘We see RFID technology is anything that really allows you to reduce inventory while increasing on-shelf availability as something worth pursuing’ Corsten and Gruen (2006, p. 11). Wal-Mart holds approximately US$20 billion in inventories and has an annual inventory turnover rate of 6; increasing inventory turns from 6 to 12 could free up $12 to $14 billion in cash per annum (Corsten & Gruen 2006, p. 13). An analysis of OOS’s by Corsten and Gruen (2003, pp. 605–606) found that the average OOS rate for 40 studies was 8.3% and that 75% of the responsibility rests at the store level. RFID applications at the retail level have reduced stock-outs, improved inventory accuracy, increased sales, and speed up the goods receipt process. Table 9 illustrates the empirical evidence of RFIDs in the retail sector.
5.2.2 Empirical evidence of RFID in logistics providers

Benefits of RFID for logistics providers have been identified for a variety of warehouse and transportation processes and activities. Table 10 demonstrates the empirical evidence of RFID in logistics processes including receiving, shipping and inventory control, as well as various yard management activities.

<table>
<thead>
<tr>
<th>Processes</th>
<th>Empirical Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiving</td>
<td>Arrival inspection time: reduced from 10% to 50% (Holmqvist and Stefansson 2006, p. 265).</td>
</tr>
<tr>
<td></td>
<td>Check-in and trucks unload: reduced by 15 to 20 minutes (Visich et al. 2009, p. 1299).</td>
</tr>
<tr>
<td></td>
<td>Order verification: reduced from 20 seconds to 5 seconds (Visich et al. 2009, p. 1299).</td>
</tr>
<tr>
<td></td>
<td>Productivity for receiving goods: 57% (Bachelard 2006, p. 1).</td>
</tr>
<tr>
<td></td>
<td>Time to process a delivered pallet: reduced 51% (Visich et al. 2009, p. 1299).</td>
</tr>
<tr>
<td></td>
<td>Time to process an order for shipment: reduced from 45 minutes to 6 minutes, or reduced to 20 seconds compared with 80 seconds to 20 minutes for a bar code system, or reduced by 80% (Wessel 2008, p. 1).</td>
</tr>
<tr>
<td></td>
<td>Pallet build speed: reduced from 90 to 11 seconds (Visich et al. 2009, p. 1299).</td>
</tr>
<tr>
<td></td>
<td>Time to load a truck: reduced from 50 minutes to 20 minutes, 40% faster (Swedberg 2007a, p. 1).</td>
</tr>
<tr>
<td></td>
<td>The accuracy of pallets shipping to customers: increased from 92% to 97% (Visich et al. 2009, p. 1300).</td>
</tr>
<tr>
<td></td>
<td>Invoice discrepancies: reduced from 80% to 0% (Visich et al. 2009, p. 1302).</td>
</tr>
<tr>
<td></td>
<td>Stock availability: 10% to 11% increase (Visich et al. 2009, p. 1299).</td>
</tr>
<tr>
<td></td>
<td>Lost goods: 18% to 20% reduction (Visich et al. 2009, p. 1300).</td>
</tr>
<tr>
<td></td>
<td>Inventory count accuracy: increased from 95% to 99% (O’Connor 2007, pp. 1-2).</td>
</tr>
<tr>
<td></td>
<td>Stock turnaround: increased from 5.5 to 6 (Visich et al. 2009, p. 1302).</td>
</tr>
<tr>
<td></td>
<td>Gate personnel productivity: improved 50% (Visich et al. 2009, p. 1299).</td>
</tr>
<tr>
<td></td>
<td>Reduced labor: 2 persons by up to 60 hours (Visich et al. 2009, p. 1299).</td>
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<tr>
<td></td>
<td>Reduced tractors: 120 to 67 per year (Visich et al. 2009, p. 1302).</td>
</tr>
<tr>
<td></td>
<td>Container locating: from 4 to 12 hours to immediately (Visich et al. 2009, p. 1300).</td>
</tr>
<tr>
<td></td>
<td>Gate efficiency: improved 75% (Visich et al. 2009, p. 1299).</td>
</tr>
</tbody>
</table>

Table 10: Empirical evidence of RFID in the warehouse and distribution centres
5.2.3 Empirical evidence of RFID in manufacturing

RFID has been used in a number of manufacturing applications for many years. According to Visich (2009, p. 1302) the automotive industry was one of the first manufacturing groups to use RFID technology to control and track products moving on assembly lines, and the reusable part bins that fed the line. Table 11 shows the empirical evidence of RFID in the manufacturing environment.

<table>
<thead>
<tr>
<th>Processes</th>
<th>Empirical Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production Planning</strong></td>
<td>Production planning accuracy: improved 29% (Visich et al. 2009, p. 1302).</td>
</tr>
<tr>
<td><strong>Procurement</strong></td>
<td>Procurement cost: reduced 11% (Visich et al. 2009, p. 1302).</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td>Production labor cost: reduced 17% (Visich et al. 2009, p. 1299).</td>
</tr>
<tr>
<td></td>
<td>Production cycle time: reduced from 88 to 46 minutes (Visich et al. 2009, p. 1300).</td>
</tr>
<tr>
<td></td>
<td>Production capacity: increased 6.5% (Visich et al. 2009, p. 1300).</td>
</tr>
<tr>
<td></td>
<td>Production lead time: reduced 27% (Visich et al. 2009, p. 1300).</td>
</tr>
</tbody>
</table>

Table 11: Empirical evidence of RFID in manufacturing

5.2.4 Empirical evidence of RFID in the whole supply chain

It has been noted by a large number of authors that the highest level of benefit from RFID will occur when RFID is implemented across multiple SC partners. In this part the thesis presents the empirical evidence of RFID benefits for open-loop and closed-loop SC’s. Table 12 illustrates the empirical evidence in open-loop SCs and Table 13 illustrates empirical evidence of RFID in closed-loop SCs.

<table>
<thead>
<tr>
<th>Processes</th>
<th>Empirical Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supply Chain Response Time</strong></td>
<td>Supply chain response time: reduced from 7 to 5 days (Swedberg 2007b, p. 1).</td>
</tr>
<tr>
<td></td>
<td>Inbound and outbound through-put time: reduced by 50% (Visich et al. 2009, p. 1300).</td>
</tr>
<tr>
<td></td>
<td>Handling time: reduced by 50% (Visich et al. 2009, p. 1299).</td>
</tr>
<tr>
<td></td>
<td>Delivery time: reduced from 28 to 16 days (Collins 2006, p. 1).</td>
</tr>
<tr>
<td><strong>Supply Chain Cost</strong></td>
<td>Labor cost: reduced by 25% (Visich et al. 2009, p. 1299).</td>
</tr>
<tr>
<td></td>
<td>Inventory cost: reduced from $127 million to $70 million (Collins 2006, p. 1).</td>
</tr>
<tr>
<td></td>
<td>Product loss: 10% reduction (Swedberg 2007c, p. 1).</td>
</tr>
<tr>
<td><strong>Supply Chain Efficiency</strong></td>
<td>Number of goods processed: doubled or tripled (Visich et al. 2009, p. 1300).</td>
</tr>
<tr>
<td></td>
<td>Rush order processing: reduced from 6 hours to 2/3 hours (Visich et al. 2009, p. 1300).</td>
</tr>
<tr>
<td><strong>Integrated Supply Chain Benefits</strong></td>
<td>Supply chain cost: reduced by 75%. Revenue: increased by 10%. Capacity: increased up to 15%. Process lead time: reduced by 70%. Customer complaints: reduced 22% (Ustundag and Tanyas 2009, pp. 29-30).</td>
</tr>
<tr>
<td></td>
<td>Average delivery time: reduced from 28 to 16 days. Supply backlog: reduced from 92,000 shipments to 11,000 (Collin 2006, p. 1).</td>
</tr>
</tbody>
</table>

Table 12: Empirical evidence of RFID in open-loop SC’s
Finally, RFID technology is firmly establishing itself as the way forward for successful and sustainable SC performance. The promise of RFID is to help companies succeed in the following areas:

**Automation** - reducing manual processes through automated scanning and data entry improves productivity, thus allowing resources to be reallocated to higher value activities.

**Integrity** - improving the integrity of real-time supply-chain information, with increased authentication and security and tracking capabilities, thereby reducing errors, shrinkage and counterfeiting while improving customer satisfaction.

**Velocity** - minimizing the time spent finding and tracking needed assets, in turn increasing product flow and handling speeds.

**Insight** - providing the real-time information needed to make faster, better-informed decisions and the ability to be more responsive to the customer.

**Capability** - providing new applications and quality to meet supply-chain partner demands and enhance customer experiences.

### Table 13: Empirical evidence of RFID in Closed-Loop SC’s

<table>
<thead>
<tr>
<th>Processes</th>
<th>Empirical Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reusable Assets</strong></td>
<td>Read time for reusable assets: reduced by 83% (Wilding and Delgado 2004b, p. 32).</td>
</tr>
<tr>
<td></td>
<td>Shrinkage: reduced by 15% (Wilding and Delgado 2004b, p. 32).</td>
</tr>
<tr>
<td></td>
<td>Container loss: reduced from 4% to 2% (Wilding and Delgado 2004a, p. 44).</td>
</tr>
<tr>
<td></td>
<td>Container cycle time: reduced from 47 to 40 days (Visich et al. 2009, p. 1302).</td>
</tr>
<tr>
<td></td>
<td>Container purchasing cost: reduced by 4 million pounds per year (Wilding and Delgado 2004a, p. 44).</td>
</tr>
</tbody>
</table>
CHAPTER SIX

6 CASE STUDIES

RFID is considered in IT terms as advancement for retail business (Banks et al. 2007a, p. 347). It is an emerging technology that is high on the priority list of some international retailers such as Wal-Mart in the U.S. and the Metro Group in Germany. It is anticipated that this technology will be adopted worldwide in retail businesses by 2015. It will significantly revolutionise the way in which retail businesses are operated and managed today.

The appeal of this technology lies in the visibility that RFID brings to inventory management and the SC (Banks et al. 2007a, p. 347). It can transmit information even when it is buried under layers of product and materials. Such capability provides opportunities to improve the retail operation in terms of efficiency and effectiveness, and also have the potential to significantly reduce the operational cost of bringing products to consumers in retail stores.

Retail leaders, including Wal-Mart and Metro Group, have already adopted RFID in many ways. RFID-enabled solutions were introduced in the Wal-Mart system at the beginning of 2005. Over 300 Wal-Mart suppliers used RFID tags by the end of 2006, and it was expected that another 300 suppliers would be RFID compliant by the end of 2007, bringing the total to 600 (Banks et al. 2007a, p. 347). The German retailer Metro Group has taken an even more aggressive approach. Since August 2006, the group has deployed second generation RFID tags to the Point of Sale (POS) cases such as the Future Store in Rheinberg and at Real, an important step to further improve goods availability for consumers (Metro Group 2007).

RFID provides benefits not only to the retailers but also to suppliers and even the customer such that shopping becomes a lot more convenient and time-saving.
6.1 Metro Group – Case Study 1

6.1.1 Metro Group history

Metro was founded by Otto Beishem in 1964 when the first Metro Cash & Carry store commenced trading; Metro began as a wholesale operation serving commercial clients (Ton et al. 2009, p. 4). Based on the rapid growth in Germany, Metro AG was formed through a merger of the retail companies Asko Deutsche Kaufhaus AG, Kaufhof Holding AG and Deutsche SB-Kauf AG in 1996 and by the end of the same year Metro AG became one of the 20 largest publicly listed companies in Germany (Metro Group 2012). It also advanced its internationalisation process after the company expanded its wholesaling operations within Europe in the 1970s (Ton et al. 2009, p. 4). Metro AG very soon started the international expansion with sales abroad reaching 7.1% of total sales in 1997 rising to 39.2% in 1999. In 2000, Metro AG developed into an internationally oriented company with decentralised management teams. The share of its turnover generated outside Germany grew to 42.2%. At present, the group employs approximately 220,000 people in 22 countries.

In November 2002, Metro AG took a further step in consolidating its position as a modern, international wholesale and retail company. From this point on, the company presented itself on a worldwide scale as Metro Group. By the end of 2004, Metro Group was active in 30 countries worldwide. Metro Group further advanced its technological progress in commerce with the opening of its RFID Innovation Centre in Neuss and the implementation of the forward-looking technology RFID. In 2007 with the comprehensive implementation of the RFID in Germany, Metro Group ensured an even better SC efficiency. Deliveries were automatically registered at 180 locations of Metro Cash & Carry and Real as well as in the central warehouses of Metro Group Logistics (MGL) (Metro Group 2012).

Nowadays, Metro Group is one of the world’s leading retail and wholesale companies. The operating business system of Metro Group involves self-service wholesale trade, hypermarkets, consumer electronics stores, department stores and online trading. Metro Group has four sales divisions – Metro Cash & Carry, Real, Media Markt & Saturn and Galeria Kaufhof. For more details about Metro Group sales see Appendix A8 (pp. 111–112).
By 2011, with sales of €66.702 billion, Metro Group has become one of the most important international retailing companies. For more details about Metro’s financial statements see Appendix A9 (p. 113). The company operates at more than 2,202 outlets in 33 countries and employs about 280,856 employees from 180 nations. They conduct their business activities autonomously in the marketplace and provide to private and professional customers in 33 countries across Europe, Asia and Africa with a comprehensive range of products and services. Metro Group’s strategy is designed to create economic, environmental and social value on behalf of customers, employees, investors and society (Metro Group.com 2012).

6.1.2 Metro Group and RFID

RFID is technology that allows data to be registered automatically via radio waves (Tajima 2007, p. 262). RFID is a permanent fixture in many economic sectors. Companies from the retail, logistics, consumer goods and automotive sectors in particular have discovered the benefits of contactless data transmission. However, the potential of the technology has by no means been fully tapped. Experts predict that the worldwide market volume for RFID will increase five-fold over the next ten years, from approximately €5.3 billion in 2008 to approximately €16.5 billion in 2018 (Chang et al. 2010, p. 71). German companies not only make up a significant share of RFID users, but many are also key producers of the technology. Medium-sized companies in particular have become competitive high-performance providers. The spectrum of goods and services ranges from transponders for tagging products to software components and complete systems. Reports indicated that the RFID business in Germany could increase its sales income to around €1.4 billion by 2010 (Metro Group 2008). Bilge and Ozkarahan (2004, p. 152) state that RFID technology has been adopted by and diffused into a variety of enterprises to achieve cost savings and increased efficiency. Based on Chang et al. (2010, pp. 71–72) RFID technology yields several significant benefits within the SC. Among others, automated data tracking without human intervention offers faster data processing, more accurate maintenance of the inventory records, and advanced shipping notices. As a result, product shrinkage, transaction errors, misplaced products, and incorrect product identification can all be reduced. Zhu et al. (2011, p. 157) show through a case study, that information collected by RFID can be valuable to both the retailer and the
suppliers. They also show that the logistical performance can be improved through RFID.

6.1.2.1 Drivers of implementing RFID

The main drivers that compelled the Metro Group to implement RFID were as following (Sectoral e-Business Watch 2008, p. 106):

- Achieve higher visibility, accuracy, productivity and efficiency of SC operations;
- Optimise inventory levels, minimise stock losses and improve working capital management;
- Optimise promotion management efficiencies;
- Reduce OOS’s with the aim to achieve top-line and bottom-line gains, but also improve customer service levels;
- Enable fully automated replenishment efficiencies as the ultimate long-term goal for the Metro Group;
- Benefits of item-level tagging for the customer experience, store inventory management and store workforce efficiencies.

6.1.2.2 Overview of implementing stages

Metro Group, as one of the largest retailing companies around the world, started deploying RFID along its SC at the end of 2004, one of the world’s first major retailing companies to do so. The step-by-step deployment involved introducing RFID from manufacturers’ production sites all the way to the incoming goods portals in the stores and beyond. Using this technology, the group has been able to optimise its logistics and warehouse management, speed up operating procedures, and improve the availability of goods for its customers. In 2006, selected suppliers were tagging cartons with transponders. In line with this development, Metro Group switched its RFID processes to the new EPC global Class 1/Gen. 2 standard. This step brought a considerable increase in performance and also provided a single standard with which suppliers and retailers could work (Collins 2006a, p.1). By the end of 2007, Metro Group had already introduced RFID at around 400 locations throughout Europe, including all of its German Metro Cash & Carry wholesale stores, nine distribution centres belonging to the group logistics provider MGL and the majority of its Real hypermarkets (Metro Group 2008).
Metro Group started an item-level field trial at Galeria Kaufhof Essen in September 2007. Since then, UHF RFID tags have been applied at the Kaufhof apparel distribution centre, for over 30,000 items in stock in the outlet. RFID gates equipped with motion sensors capable of automatically activating readers when needed, are placed at the backroom goods receiving area and at all transition points from the warehouse to the front store as well as inside the dressing rooms. At the checkout desk EPC-compliant RFID tags are read without requiring physical or visual contact. Using mobile RFID readers the staff can check which items are available in the front store and where they are located. Tags are also used to enable item localisation. Store assistants can thus provide real-time information on item availability, supporting customer service enhancements and optimising inventory management. Information is provided to consumers with clear signs at the shop, brochures and clear labelling of all readers with the EPC global logo (Metro Group 2008).

In 2008, the company also initiated the nationwide rollout of RFID in France, where its 89 Metro Cash & Carry wholesale stores now process around 1.3 million pallets every year using this technology. Metro Group is working very closely here with the logistics company DHL, which tags all pallets for Metro France with transponders (Metro Group 2008).

Around 180 consumer goods companies are already involved in the introduction of RFID in Germany. They tag all pallets bound for Metro Group’s stores and warehouses with transponders. These Smart Chips store the EPC, which provides every pallet with a unique identity. At the outgoing goods portal, an RFID reader registers the EPC and in a split second, compares the delivery with the actual order. If everything is correct, the goods are approved for dispatch and the producer sends an electronic confirmation to Metro Group. Trucks then transport the delivery to one of the central distribution centres. Here, the pallets are registered by the RFID readers at the incoming goods portal. Warehouse staffs then re-sort the pallets for the various Metro Group stores and reload them onto delivery trucks. At the outgoing goods portal there is another automatic check via RFID. The information and the delivery date are electronically transmitted to the stores. When the trucks are unloaded at the store, RFID readers automatically compare the delivered goods with the order. The incoming goods are then entered into the database. This means that
store managers always know exactly which products they need to reorder and when (Metro Group 2008).

RFID is also making a major contribution when it comes to optimising warehouse management processes, such as, for instance, at Germany’s largest deep-freeze warehouse, the MGL distribution centre in Hamm in North Rhine-Westphalia. Here, RFID readers are installed, not only in the incoming goods portals, but also in the forklifts. The 11,000 storage locations are tagged with transponders, which mean that they too have a unique identifier. Employees tag the incoming pallets with Smart Chips. The warehouse management system automatically assigns a shelf location to all goods deliveries. RFID is also a great boon to the forklift operator; first it helps them check whether they have picked up the right pallet and then, once they have reached the high shelf, an automatic reconciliation between shelf location and goods delivery takes place. This system makes it possible for the employees working in incoming goods and storage to process and document a monthly volume of 15,000 pallets. In Hamm, Metro Group has also been able to show that RFID continues to work reliably even at temperatures as low as minus 24 degrees Celsius (Metro Group, 2008). Figure 10 illustrates the Metro Group RFID implementation timeline.

According to the Metro Group (2008), in the next 10 to 15 years Metro Group expects that mainstream adoption of RFID will lead to:

- Positive effects on logistics efficiencies that can result from RFID adoption may also contribute to the achievement of environmental sustainability objectives, essentially by reducing pollution caused by commercial vehicles due to optimised asset management and dynamic transportation routing abilities;
Attainment of lean SC capabilities in distributive trades leveraging on the combined usage of RFID and smart sensors;

Provide a better consumer experience and front-end retail innovation, for example, with the introduction of interactive digital advertising systems, smart checkout and intelligent shelves. These latter are shelves equipped with RFID readers that can automatically send information to the merchandise management system when goods are removed or incorrectly shelved, so that staff can restock the shelves or re-arrange the products. An interesting application of intelligent or smart shelves is also the possibility to enable new forms of communications and assistance to consumers via digital displays that can be triggered by goods movement from the shelves.

6.1.3 Metro Group future store initiative

The Metro Group Future Store Initiative is a driving force for the modernisation of the retail industry. Partners from the retail, consumer goods, IT and service sectors are driving forward the development and implementation of innovations that can make shopping more convenient for consumers, providing them with better service and at the same time, increase the efficiency of retail processes.

At the Future Store, Metro Group is testing groundbreaking technologies and innovative concepts for the retailers of tomorrow. The company’s aim is to tailor product ranges and services to perfectly match the needs of consumers. ‘The concepts and technologies that prove successful in Toenisvorst will be introduced successively at stores belonging to our sales brands’, says Dr. Eckhard Cordes, Chairman of the Management Board of Metro Group. ‘As a result of that, the Future Store is strategically important for the future development of the entire group’. In the Metro Group Future Store, the RFID’s interaction with other different technologies is being tested under real life conditions. The aim here is to reach market maturity of currently realisable technologies that would change the future of retailing.

After one year of pilot testing of the different technologies, Metro claims significant achievements in the Future Store Initiative due to the implementation of RFID and other technologies. Metro states that process efficiency has risen by 12% to 17%, theft and losses have decreased by 11% to 18% and merchandise availability
has increased by 9% to 14% due to RFID. Metro does however admit to certain problems during this pilot phase. The on-shelf RFID readers have some ‘blind spots’ where they did not reliably register products and also have problems detecting liquid and metal products. Metro also reports that the cost of the tags, readers, engineering and cabling necessary for a full RFID implementation throughout the whole SC is expensive and that this is restrictive even for retailers of the size of Metro (Metro Group 2011). The following are some of the most important technologies that have been tested in the Future Store Initiative:

1- **RFID**: (Facilitates quality control and demand-driven production).

- **Radio Frequency Identification**:

  RFID plays a key role at the Future Store. The automatic product recognition technology is an intrinsic part of the store’s quality assurance system for meat products prepared in the in-house butchery. These products are fitted with Smart Chips and displayed in the Smart Freezer, which monitors stock levels and the best-before dates on all items. Every time a customer removes a product, integrated RFID readers register this automatically. This makes it possible to plan the in-house production of fresh meat products extremely precisely and also significantly contributes toward the ongoing optimisation of quality assurance processes (Metro Group 2010).

- **Inventory management**:

  It is in the area of inventory management where RFID technology really stands out in driving innovation in the Future Store. RFID technology is used in part as an anti-theft measure but also in order to better track, replenish and display stocks. RFID is used both at the warehouse and at the store level. RFID tags are placed on all pallets and crates that leave the Metro Group Distribution Logistics warehouse. RFID-readers at the exit and entry zones of warehouses and stores then record the flow of goods. Metro also installs RFID readers in backroom areas of the store. This enables the processing of exact information about where goods are located in the backroom into the RFID goods control system. When goods are moved from the backroom to the actual sales area of the store, RFID readers also record this transfer into the goods flow system.
Furthermore, Metro uses RFID technology in the actual shelves in which products for sale are placed. These are called Smart Shelves which have an integrated RFID-reader that automatically recognises the products placed on them. This method is used for reducing the incidence of OOS situations, since misplaced or missing items are automatically registered. In addition, Metro has developed a warning function that detects when a shelf is running low on stock, signals the need to transfer products from backroom areas or the warehouse and even determines how urgent the transfer. RFID can be used to eliminate OOS-occurrences and to ensure that shelves will always be labelled with the right price for the product.

An additional major advantage of the RFID system over the traditional barcode system is that it allows Metro to store much extra product information in addition to the price. Information that could potentially be stored on an RFID tag includes product origin data (such as date of production or harvest), transport data, delivery destination, supplier, internal item number, data about storage temperature, best-before date, batch numbers and recycling information. When the RFID tags are read, it could then be possible to retrieve the entire history of items from their production through to their recycling or disposal. A particularly important application for fresh or frozen produce is the logging of applied temperature data on the RFID tags (Metro Group 2010).

2- **Mobile Shopping**: (More convenience, more information and an enhanced shopping experience). For more information about mobile shopping see Appendix A10 (p. 114).

3- **Innovative technologies and new checkout systems**
Even greater convenience is provided by the state-of-the-art payment options, for instance, the new Pay by:
- Fingerprint system;
- Smart Checkout systems.

The Future Store trialled a variety checkout systems. This included check out through the Personal Shopping Assistant (PSA) as well as the self-checkout:
- Personal Shopping Assistant (PSA);
- Self-Checkout.

For more information about innovative technologies and new checkout systems see Appendix A11 (p. 115).
4- **Comfort Shopping**

The following are the innovations tested as part of the comfort shopping program:

- Electronic Advertising Displays;
- Intelligent scale;
- Electronic Price Labels.

For more information about comfort shopping and new checkout systems see Appendix A12 (p. 116).

- **Increasing the use of Future Store technologies**

Customers are greeting the technologies deployed by the Metro Group in its Future Store in Rheinberg with enthusiasm. This is the result of a study conducted by the Boston Consulting Group marking the two-year anniversary of the Future Store. The unique store, opened in April 2003, serves the Metro Group and its partners to test innovative retail technologies.

Since its opening, Future Store has increased its customer base by almost 30%. The study, based on a customer survey, shows that there has also been a further rise in the number of customers who have used at least one of the new technologies from 79% to 85%. Even older aged consumers have come to appreciate the additional features, in particular the Smart Scales. Before March 2004, 52% of customers aged 60 or over had tested the system – today; the figure has risen to 59%.

Above all, the automatic self-check-outs have become a standard part of everyday shopping in Rheinberg. More than half of the customers have already used them at least once to pay for their purchases. After the highly successful introduction of the technology in Rheinberg, it is now deployed in over 40 stores of the sales divisions Extra, Real and Praktiker. In the same time frame, the number of locations featuring self-check-outs has doubled. Praktiker plans to introduce this in its outlets abroad.

The Information Terminals have also firmly established themselves. The number of customers who have used the service has risen from 51% to 58%. A recent new offering is the availability of information on the origin and quality of foodstuffs at the Information Terminals. This service is currently being tested for eggs, but will shortly extend to meat, fruit and vegetables. This makes the Metro Group the first retailer in Germany to offer its customers full traceability of food products in direct compliance with the new EU directive (Metro Group 2005).
The Metro Group case shows a great integration effort in the retail industry. The case has illustrated that RFID offers the potential to significantly reduce the costs of getting products to consumers and into stores. In the Future Store, RFID technology and applications has enabled Metro Group to: (1) increase accuracy; (2) gather information at new points in SC; (3) make additional data available; (4) permit new kinds of collaborative sharing of data between retailers and manufacturers; and (5) provide interactivity between store and customer devices.

6.1.4 Metro Group RFID innovation centre

In order to provide support for Metro’s industry partners, in 2004 the Metro Group opened the RFID Innovation Centre in Neuss, to create an information and development platform that is unique in Europe. Here, the suppliers, IT partners as well as representatives of the sales brands had the opportunity to test the technology under real-life conditions (Ton et al. 2009, p.7). More than 40 systems were available, allocated to five different functional applications:

- RFID in order picking;
- RFID in warehouse management;
- RFID in department stores;
- RFID in stores of the future;
- RFID at home.

At the Innovation Centre, the Metro Group advances the further development of the RFID technology in retailing together with its technology partners. The focus here is on the practical application of RFID at all levels of the process chain and the international standardisation of the data records which are decisive for the further implementation of this technology of the future over the next few years.

Metro Group RFID Innovation Centre is also home to the European EPC Competence Centre (EECC), which is jointly sponsored by Metro Group, DHL and GS1. The centre offers all users, suppliers and service providers the opportunity to comprehensively test the performance of transponders using a series of standardised procedures. The EECC is the first such centre in Europe to be awarded the title ‘EPC Global Performance Test Centre’. The facility has also run comprehensive training programs and organise regular information sessions on RFID and the EPC.
6.1.4.1 RFID in picking: (In the right place at the right time)

Picking is the name given to the process at a distribution centre where the items required for an individual store are selected to be shipped out. In the Innovation Centre, RFID-tags are placed on both products and transport units in order to boost the efficiency and accuracy of picking. Also RFID technology makes it possible to carry out multiple processes automatically and simultaneously. In this way, the time required for order picking is cut down considerably (Metro Group 2007, pp. 12–14).

6.1.4.2 RFID in warehouse management: (Keeping an eye on deliveries)

Warehouse management is primarily concerned with registering the entry and distribution of goods and the monitoring of stock levels. This process is made more efficient through RFID-gates at warehouse entries. In particular RFID makes it easier to sort pallets into the high shelves. In the Innovation Centre, ultra-high frequency handheld readers are used to read pallets at a distance of up to four metres (Metro Group 2007, pp. 15–20).

6.1.4.3 RFID in the department store: (Customer service, made to measure)

The use of RFID technology in stores has already been discussed above in the material on the Future Store Initiative. Additional features trialled in the Innovation Centre that has particular application to department stores, include the ‘Intelligent Change Room’. In this feature, an RFID reader in the change room is able to read the RFID tag in the clothing item brought by the customer into the room for trial and then provides additional information about the particular item to the customer. Another feature is the ‘Virtual Catwalk’ where a product selected by the customer is recognised by an RFID reader which then enables the customer to obtain a virtual fashion consultation about the item (Metro Group 2007, pp. 21–26).

6.1.4.4 RFID in the supermarket: (The shopping experience of the future)

Most of the tests of RFID technology applicable to supermarkets have already been detailed above in the description of the innovations tested in the Future Store. These include smart shelves, intelligent scales, multimedia displays and self-checkout. The Innovation Centre also tests RFID-equipped scales for staff use that combines with an RFID-bracelet worn by the employee that assigns the sale to the particular employee (Metro Group 2007, pp.28–32).
6.1.4.5 RFID in the private household: (Little helpers around the house)

The Innovation Centre seeks to show how RFID technology could help consumers keep fresh-groceries in stock in their homes at all times and allow planning and shopping at the store easier. The particular RFID innovations that help to achieve these goals are the smart fridge and the intelligent freezer. The smart fridge works by having an interface that allows the consumer to register the minimum amount and selection of products that should be in the fridge. The smart fridges then detects if either a product type requires replenishment or if the expiry date on an item is approaching and goes on to generate an electronic shopping list for items stored in the fridge. The intelligent freezer works in a similar way and also makes it possible to view all products and their location in the freezer even via the internet as the consumer can label the products with reusable smart chips (Metro Group 2007, pp. 34–35).

6.1.5 Benefits experienced by Metro Group due to RFID

The growing interest in the use of RFID on the part of the retail industry today has sparked an intense debate in academia and in practice regarding the benefits to be expected. Retail giants in the US and Europe have made many efforts to convince suppliers, logistics service providers, and companies from other industries of the positive impact of RFID on SC performance (Thiesse et al. 2009, p. 593). The Metro group had recognised the benefits of RFID before they rolled it out over their entire organisation. They did this by implementing RFID on a small portion of their business first. In 2004 it rolled out the RFID technology to the goods received in individual test stores and distribution centres. The positive results from these tests and the development of the new chip standard then created the preconditions for a group-wide rollout. As Frans Muller, Member of the Management Board puts it: ‘We will forcefully drive the area-wide deployment of RFID this year (i.e. 2004) in order to systematically tap the large potential of this technology’.

They realised that the implementation of RFID would give them a competitive edge over other competing businesses. This is evident from the statement by Peter Kirschbauer, member of the extended management board, SAP AG:

With the help of RFID technology companies can use real-time data and improved data visibility and accuracy to transform their SC into adaptive business networks. This level of innovation will be a key factor in maintaining a competitive
edge in the future and offering customers the quality of service they have come to expect. (Metro Group 2007)

John Davies, Vice President, Solutions Market Development Group, Intel Corporation adds: This announcement is not only about technology and business process - it is about industry leadership. RFID technology and the EPC standard have the potential not only to make inventory and SCM more efficient but to create a new shopping experience for the consumer. (Metro Group 2007)

‘The extension of the use of RFID at Real and Metro Cash & Carry demonstrates how the potential of RFID in retail logistics can be leveraged’, said Dr. Gerd Wolfram, Managing Director of Metro Group IT. RFID appreciably accelerates the handling of incoming goods, thus reducing truck idle times and contributing to a further optimisation of the transport routes. ‘Thanks to the RFID labels’, each pallet can be registered automatically and deliveries can be checked for completeness within seconds, thereby decisively improving the accuracy of inventory management (Metro Group 2008). According to Sectoral e-Business Watch (2008, p. 109), the following improvements resulted from RFID implementation in the Metro group:

- **Supply process efficiency**: Significant overall improvements were recorded based on a full RFID-deployment scenario. Compared to manual barcode processing, RFID enabled accelerated goods receipt, reduced idle time via automatic monitoring and inventory management optimisation, improved process flow and resulted in fewer shelving errors.

- **Loss/theft shrinkage**: 11% to 18% of reduction was experienced, depending on product category and the utilisation of RFID on the case level. RFID-based EAS systems increased efficiency gains, by enabling source-tagging approaches.

- **Sales and customer service**: 10% to 20% reduction of OOS situations was recorded. Improved merchandise availability greatly influenced sales performance, which in Metro Group’s experience grew by up to 15% to 20% (although not completely attributable to RFID integration).

- **Counting only the automated dock-door incoming goods processes** (2 out of 11 major processes in retail logistics) the Metro Group experienced the combined use of RFID and EDI resulting in total savings of €8.5 million per year in Germany considering the Metro Cash & Carry, Real and the distribution warehouses.
• CPG suppliers also achieved significant cost reductions. As an example, order picking efficiencies improved resulting in 16 seconds per pallet being saved. In addition, the goods receiving process also became faster at the retail distribution centre, shortened waiting time for delivery trucks, and thus further reduced logistics cost.
• Electronic dispatch note led to cost savings of up to €2.84 for each dispatch note.
• More effective promotions were enabled via item-level RFID tagging and higher working capital efficiencies were achieved by attaining full inventory visibility of items.

In addition, Ton et al. (2009, pp. 5–9) state that the effects of the process improvements in stores due to the use of RFID gave the following benefits to Metro Group’s retailing activities and the overall retail value chain:
• Automation provided savings in labour costs and time;
• New process was more efficient, faster, and less complex;
• Reduction of inventory counts and improved product availability;
• A collaborative benefit, achieved from data sharing between Metro Group and its suppliers;
• By gathering purchasing data the at check-out, the future stores and even stores in general started using item level RFID data for providing product information to consumers on the one hand and customer information to stores on the other.

Figure 11 demonstrates the increased saving rate of the Metro Group. This increase occurred as a result of many different factors, and one of the main factors is using RFID tags in the case and pallet.

![Figure 11: Metro Group savings](www.slideshare.net)

It is evident that from 2005 to 2009, the savings on pallets and cases have been increasing. Figure 12 demonstrates the rate of growth of Metro Group sales. This
growth occurred due to many factors. One of the main important factors was the use of RFID technology in its SC.

![Figure 12: Metro Group sales growth (www.slideshare.net)](image)

Again it can be seen that the trend in sales revenue is upward, indicating increasing revenue though with growth tapering in the last three years.

![Figure 13: Metro Group net sales (Metro Group annual reports, 2002 to 2011)](image)

As shown in Figure 13, following the implementation of RFID technology in the year 2004, net sales have continued to rise. This is an indication that RFID technology is one of the most important factors that have an impact on increasing of the net sales.

6.1.6 Metro Group Services

6.1.6.1 Metro Group Logistics (MGL)

Inbound transportation as well as outbound transportation at Metro Group is managed by MGL, the logistics services and competence centre of the Metro Group. Through its distribution and procurement logistics networks, MGL controls the merchandise flows of the Metro Group sales lines, Metro Cash & Carry, Real, Media
Markt and Saturn as well as Galeria Kaufhof. For more information about MGL see Appendix A13 (p. 117).

6.1.6.2 Metro Group Buying (MGB)

MGB GmbH is the strategic buying organisation for Metro Group with all sales lines. Metro Group is one of the world’s largest trading groups for the sales divisions: Metro Cash & Carry, Real, Media Market, Saturn and Galeria Kaufhof. As a result, this company is responsible for the procurement of food and non-food products in Germany and internationally. It pools purchasing volumes to guarantee the best price and conditions. In 2011 the group reached sales of approximately €66,702 billion and has a headcount of some 280,856 employees operating in 33 countries (Metro Group 2011).
6.2 Wal-Mart – Case Study 2

6.2.1 Wal-Mart history

In-depth look at Wal-Mart’s history is important in order to understand its rapid growth and relationship with its employees and customers, and how its history has shaped the company’s standing and reputation. The first Wal-Mart was opened in 1962 by founder Sam Walton in Rogers, Arkansas with the help of Bud Walton. After five years, the company had increased to 24 stores within Arkansas and sales had reached US$12.6 million. In 1968 Walton opened his first stores outside Arkansas, in Sikeston, Missouri, and Claremore, Oklahoma, and after one year in 1969 incorporated all of these ventures as Wal-Mart Stores (Wal-Mart Stores 2012).

In 1974 Wal-Mart continued its expansion into eight states: Arkansas, Kansas, Louisiana, Missouri, Oklahoma, Tennessee, Kentucky and Mississippi. By the middle of the decade, Wal-Mart had over 7,500 employees. The company had two acquisitions, 16 Mohr-Value stores in Michigan and Illinois, and the Hutcheson Shoe Company, leading to the introduction of the Wal-Mart pharmacy, auto service centre and jewellery divisions. The 1990s also proved to be fruitful for the company, being named the number one retailer in the nation and opening a Wal-Mart’s Visitor’s Centre in Walton’s original 5–10 stores in Bentonville, Arkansas. Shortly thereafter in 1995, Wal-Mart Stores Inc. operated 1,995 stores, 239 Supercenters, 433 Sam’s Clubs and 276 international stores.

According to Bhuptani and Moradpour (2005, p. 143) Wal-Mart is the largest retailer group around the world, using IT to improve its operations and to gain competitive advantage. Wal-Mart looked to IT, especially RFID technology, to further improve its operations, and further advancement such as reducing labour cost, improving inventory control and advancing market intelligence. In June 2003 Linda Dillman the CIO of Wal-Mart announced that the company had started a plan to deploy RFID along its SC, and revealed that its top 100 suppliers would be required to put RFID tags carrying EPC on pallets/cases starting in January 2005 (Seideman 2003, p. 1).
In 2005, Wal-Mart employed more than 1.6 million associates in more than 6,200 facilities around the world which included 3,800 US stores and 3,800 international units, with US$312.4 billion in sales for the year.

By 2011, with sales of US$418,952 billion, Wal-Mart was then the most important international retailing company and also the largest retailer around the world. For more details about Wal-Mart’s financial statements see Appendix A14 (p. 118). The company operates at around 10,185 stores and clubs located in 27 countries which includes stores in all 50 states in US as well as international stores (for example Argentina, Brazil, Canada, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Puerto Rico, the UK), and employs around 2.2 million employees, serving more than 176 million customers a year. Wal-Mart’s strategy is designed to provide a broad assortment of quality merchandise and services at ‘every day at low price’ (Wal-Mart Stores 2012).

6.2.2 Wal-Mart operations
Wal-Mart’s operations comprise three business segments:

1- Wal-Mart Stores
   • Wal-Mart Stores
   • Wal-Mart Super-Centres
     • Wal-Mart Discount Stores
     • Wal-Mart Neighbourhood Markets
     • Wal-Mart Express Stores

2- Sam’s Club

3- Wal-Mart International
   For more detail about Wal-Mart operations and its three business segments see Appendix A15 (pp. 119–120).

6.2.3 Wal-Mart and IT
   IT plays only a supporting role in Wal-Mart’s overall business success, but Wal-Mart must pay continual attention to advances in IT. Any emerging technology that has the potential to take significant costs out of the SC can change industry dynamics and shift the balance of power in an industry. In the mid-1980s, Wal-Mart invested in a central database, store-level POS systems, and a satellite network. Combined with one of the retail industry’s first chain-wide implementation of UPC
barcodes, store-level information could be collected instantaneously and analysed. By combining sales data with external information such as weather forecasts, Wal-Mart was able to provide additional support to buyers, improving the accuracy of its purchasing forecasts (Richard Ivey School of Business 2008, pp. 6–7). In the early 1990s, Wal-Mart developed Retail Link. At an estimated 570 terabytes – which Wal-Mart claimed was larger than all the fixed pages on the Internet – Retail Link was the largest civilian database in the world. Retail Link contained data on every sale made by the company over a two-decade period. Wal-Mart gives its suppliers access to real-time sales data on the products they supply, down to individual stock-keeping items at the store level.

In 1990, Wal-Mart became one of the early adopters of Collaborative Planning, Forecasting and Replenishment (CPFR), an integrated approach to planning and forecasting by sharing critical SC information, such as data on promotions, inventory levels and daily sales Richard Ivey School of Business (2008, p. 7). Wal-Mart’s Vendor-Managed Inventory (VMI) program (also known as continuous replenishment) requires suppliers to manage inventory levels at the company’s distribution centres, based on agreed-upon service levels. The VMI program was started with P&G diapers in the late 1980s and by 2006, had expanded to include many suppliers and SKUs Richard Ivey School of Business (2008, p. 7). In some situations, particularly grocery products, suppliers owned the inventory in Wal-Mart stores up to the point that the sale was scanned at checkout.

One of Wal-Mart’s key SC improvements is RFID. Heinrich (2005, p. 25) states that RFID systems improve flow in SC. The author notes, that the benefits are heavily based on the integrity of the system and use of the data collected automatically by SCM systems. Angeles (2005, pp. 53–54) presents cases of RFID applications and information that support the adoption of RFID technology. The author states that RFID enables SC visibility. Because RFID provides so many benefits in logistics operations, its impact on SC facilities such as warehouses are foreseeable. Twist (2005, pp. 236–237) describes how the technology affects facility operations and concludes that in particular, cross-docking warehouses will gain importance as products spend less time on shelves and loading and unloading processes are optimised. Chang et al. (2010, p. 71) note that the use of RFID has enormous potential to increase SC efficiency. Seymour et al. (2008, pp. 32-33) state that ‘modern SC has many problems which are often attributed to a lack of accurate
and integrated data’. Authors identify RFID as the most significant SC technology that has been suggested as a possible solution. RFID technology can improve products’ traceability and visibility throughout the entire SC and can increase the speed and reliability of tracking, shipping, checkout, and counting processes, which leads to improved inventory flows and more accurate information (Michael & McCathie 2005, pp. 624–626). According to Attaran (2007, pp. 251–252) RFID has demonstrated benefits for hundreds of manufacturers and retailers. Some of the critical success factors that could influence RFID adoption are: (1) top management involvement; (2) partnership with competent technology providers; (3) integrating RFID into a company’s existing IT architecture; (4) integrating the data collected by RFID systems with a company’s back-office business software, such as ERP systems; (5) determining which practices should be incorporated into their RFID systems; and (6) coordinating the receiving, manufacturing, warehousing and shipping operations once information delivered from the RFID is shared across the enterprise and plant floor.

6.2.4 RFID at Wal-Mart

IT is one of the most important resources in creating organisational value through its capability to transform the nature of products, processes, companies, industries and even competition itself (Tzeng et al. 2008, p. 601). According to Bhuptani and Moradpour (2005, p. 143) Wal-Mart is the largest retailer around the world which uses IT to improve its operations and also to gain competitive advantage. Because of that, Wal-Mart looked to RFID technology to further improve its operations, and further advancements such as reducing labour cost, improving inventory control and advancing market intelligence. The SC may be the first area in which retailers benefit from RFID, as is shown in many pilot and case studies; for example Galeria Kaufhof (Frederic et al. 2009, p. 593), and Wal-Mart (Hardgrave et al. 2008, p. 181). According to Rekik et al. (2008, p. 265), reducing inventory and OOS were the important two objectives of Wal-Mart’s RFID initiative.

6.2.4.1 Drivers of implementing RFID

The main drivers that persuaded Wal-Mart to implement RFID technology were following: (Bhuptani & Moradpour 2005, p. 143):
• Reaching higher visibility, accuracy and productivity efficiency of SC operations;
• Optimising inventory levels, minimise stock losses and improve working capital management;
• Optimising promotion management efficiencies;
• Reducing OOS aiming to reach top-line and bottom line (increase product availability);
• Improving customer service levels (creating more value for the customer).

6.2.4.2 Overview of implementing stages

Wal-Mart, the largest retailing company around the world, started the plan to deploy RFID along its SC on June 2003, when Linda Dillman, the CIO of Wal-Mart, revealed that it’s top 100 suppliers would be required to put RFID tags carrying EPC on pallets/cases starting in January 2005 (Seideman 2003, p. 1). By the end of the same year the company began a pilot project. As a result of that Wal-Mart’s distribution centre near Dallas and Texas were selected as the site for the pilot. In November 2003 Wal-Mart organised a conference for its top 100 suppliers in Bentonville to show more details of its RFID program, and to provide further clarification on the mandate which included specification for the tags to be used. This included:
• All suppliers were to tag cases/pallets by the end of 2006;
• UHF tags were to be used;
• For each current EPC global, class 0 and class 1 tags were to be used initially, with a shift to EPC Generation 2 tags. Data was to be communicated to and from Wal-Mart via Retail-Link and EDI, with no use of the EPC global Network because the standard was still under development;
• A mandatory 100% read accuracy was specific for tagged goods within 10 feet of the reader;
• Cases containing one item must be tagged (Bhuptani & Moradpour 2005, pp. 144–145).

In April 2004 Wal-Mart began its RFID pilot project by receiving cases/pallets of product with EPC tags at a single distribution centre in Texas as part of a test being conducted with eight suppliers. The tagged goods were to track goods to the back of eight Wal-Mart stores in Texas served by the distribution centre. The first
eight suppliers, which tagged just a small number of SKUs, were Gillette, Hewlett-Packard, Johnson & Johnson, Kimberly-Clark, Kraft Foods, Nestlé Purina Pet-Care, Procter & Gamble, and Unilever. In the same year Wal-Mart met with its top 100 suppliers and the next 200 suppliers in Bentonville to lay out its RFID tagging requirements and timeline. Suppliers were told that by June 2005, RFID systems would be operating in up to six of its distribution centres and 250 stores. Wal-Mart further said that it expected using EPC technology in up to 13 distribution centres and 600 Wal-Mart and Sam’s Club stores by the end of 2005 (Supply Chain Digest 2009, pp. 1–2).

In January 2005 most of the top 100 suppliers had started shipping some tagged products to three Wal-Mart distribution centres in Texas. In March of the same year, Linda Dillman, the CIO of Wal-Mart, said that the Wal-Mart was on track to support RFID capability in 600 stores and 12 distribution centres by the end of the year. Also by the end of 2005 Wal-Mart had installed RFID systems in more than 500 stores and five distribution centres. On the same date, Wal-Mart sponsored a report by the University of Arkansas’ Information Technology Research Institute. The report was based on a preliminary study of the impact of RFID on reducing retail OOS. The researchers concluded that RFID had reduced OOS at store level by 16% over non-RFID based stores (Supply Chain Digest 2009, pp. 1–2).

In March 2006 Wal-Mart started working on two ‘proof of concept’ pilot projects for using sensors along with RFID tags to track produce and environmental temperatures as the products moved along the SC. After one month in the same year, Wal-Mart said that it would phase out the use of Gen 1 tags in favour of Gen 2 by mid-year, saying it would no longer accept the use of Gen 1 tags on the cases/pallets it received from its suppliers after June 30. In the end of 2006 Wal-Mart announced that by January 31, 2007, another 500 of Wal-Mart’s 3,900 stores would have RFID readers installed (Supply Chain Digest 2009, pp. 1–2). Figure 14 illustrates the RFID implementation timeline.

![Figure 14: Wal-Mart RFID implementation timeline](Bhuptani and Moradpour 2005, pp. 145)
RFID tags have allowed Wal-Mart to increase stock visibility as stock moves in trucks, through the distribution centres and on to the stores. Wal-Mart is able to track promotions effectiveness within the stores while cutting OOS sales losses and overstock expenses. The company places RFID tag readers in several parts of the store:

- At the dock where merchandise comes in;
- Throughout the backroom;
- At the door from the stockroom to the sales floor;
- In the box-crushing area where empty cases eventually wind up.

With these readers in place, store managers know what stock is in the backroom and what is on the sales floor (Richard Ivey School of Business 2008, p. 9).

6.2.5 Benefits experienced by Wal-Mart due to RFID

Wal-Mart tapped into RFID technology with the aim to increase the efficiency of its SC. This was because they believed that RFID implementation would enhance transparency of their SC and hence would help them minimise cost and labour and strengthen inventory control. According to Collins (2005, p. 1) reducing OOSs is a problem that impacts retailers and their suppliers around the world with regard to around 8% of stock items. Based on that, University of Arkansas is carrying out research at Wal-Mart stores in order to quantify the ability of RFID to decrease retail OOSs. As a result, Wal-Mart stores with RFID showed a net improvement of 16% fewer OOS on the RFID-tagged products that were tested and also showed faster shelf replenishment of those products over products tracked via barcodes at the case level. In addition, a six-month research study by Hardgrave et al. (2008, p. 187) of 4,554 items in 24 Wal-Mart stores found that stock-outs were reduced by 26% at the 12 RFID-enabled stores. Stratification of the items by sales rate showed reductions ranging from 20% to 36% for those items with a sales rate of 0.1 to 7 units a day and 62% for items with a sales rate of 7 to 15 units per day. There was no impact on items with a sales rate of greater than 15 units a day, but 90% of the items in the study had a sales rate of three or less. However, during the course of this study, stock-outs also declined at the control stores, with the net effect being a 21% reduction in the test stores compared to the control stores. According to Kasiri et al. (2012, p. 259), by 2008 Gillette and Wal-Mart had measured how much sales would
improve through better promotion execution. They monitored the promotional items in distribution centres, the back-store, and promotional displays to provide the items on time and avoid OOS and achieved a 19% increase in their sales. Furthermore, Wang et al. (2011, p. 571) mentioned research by University of Arkansas on 24 retailers of Wal-Mart, which were divided into two different groups. Each group consisted of 12 retailers; one group used the integration of the RFID/EPC system into SC and the other group did not. The results of this research showed that the group that integrated the RFID/EPC system into the SC had a 16% decrease in the OOS rate compared to the other group without the integrated RFID/EPC system. As well, the replenishment implementing RFID/EPC was three times faster than the use of the traditional barcode. Furthermore, Wal-Mart executive VP of logistics Rollin Ford, stated that the use of RFID had reduced the number of manual orders by participating stores by 10% (Chain Store Age 2005, p. 80). Pisello (2006, p. 2) mentioned that Wal-Mart experienced a dramatic reduction of pallet-build from an existing 90 seconds to an even faster 11 seconds, a reduction of almost 90%.

According to Langford, Wal-Mart's director of transportation and RFID, the focus of the retailer's RFID has been on improving on-shelf availability and creating value not just for Wal-Mart, but also for customers, who benefit by finding the items they want to buy, and also for suppliers, who benefit from the increase in sales (Roberti 2005, p. 1–2). Wal-Mart also saw some inventory reductions due to RFID. Manual orders went down 10% to 15% in stores utilising RFID, which meant that staff were not overriding the system and ordering goods that might in fact be lying in the back of the store. But the real benefits were experienced as more cases were tagged and more data became available. Working together, Wal-Mart and its suppliers used the data to improve replenishment based on the improved visibility provided by RFID. By using data supplied by Wal-Mart and other SC partners, the company was able to tell where its products were in the SC. This provided efficiency when receiving the product at a distribution centre, picking it and shipping it to the retailer, and finally it reduced OOS’s at the retail outlet, so the product was there when the consumer wanted to buy it (Roberti 2005, p. 2). According to Bhuptani and Moradpour (2005, p. 147) improvements resulting from the Wal-Mart RFID implementation were as follows:

- Wal-Mart eliminated many manual processes including those in receiving, inventory management, shipping and payables;
Wal-Mart was able to reduce inventory shrinkage and OOS situations by automatically tracking product movement;

- Reduced number of data entry errors;
- Shoppers got a better deal as the system became more efficient;
- The right products were available at the right stores at the right time;
- Predicting product demand became easy;
- Shoppers saved time.

The above Figure 15 shows that after the implementation of RFID technology by Wal-Mart in 2004, the net sales of the organisation soared. That means implementing RFID had key role of the increasing of net sales.

The net income also rose after the RFID implementation as shown in Figure 16. Overall, the statistics show that the organisation experienced increase in profits after the implementation of the RFID technology.
6.3 Analysis of Both Case Studies Based on Performance Dimension

This research focuses on RFID technology and its implementation at two retail chains in the US and Europe that have successfully implemented this technology and identifies the impact of RFID technology on improving SC performance in the retail industry. The introduction of new technology such as RFID in the retailing business helps to mark out the moving objects in the logistic networks. Both RFID as well as barcode technology have their own advantages in the field of data collection and application areas. The aim of this chapter is to examine and compare Wal-Mart and the Metro group to identify the differences with respect to SC performance dimensions. The chapter also identifies how RFID technology improves the overall performance of retail SC by comparing the two different attributes.

6.3.1 Coordination and integration

Coordination and integration activities are considered important for inventory management and relate to activities as observed from the literature which contributes to performance improvement. The literature provides a detailed explanation for the importance of RFID in controlling inventory records for retail outlets. It is also argued that implementation of RFID has considerably reduced the need to addressing inventory record inaccuracies. Based on the adopted RFID technology, the overall cost threshold is reduced. The RFID-enabled system has the ability to replace automatic ordering in a replenishment based system in which the overall inventory at warehouses or distribution centres reduces to a level below that expected. RFID tagged products provide the stores with the advantages of tracking the location of the product and measures inventories in real-time activities. Due to such practices, demand for specific products can be reduced correspondingly and negate the potential for OOS circumstances. FMCG industries are observed to experience advantages in various ways due to the inventory monitoring using the RFID system.

From the previous section the thesis identifies Wal-Mart to be implementing inventory management since 1983. Wal-Mart was provided with various advantages due to the implementation of RFID systems. The organisation made several attempts to eliminate manual processes related to receiving, inventory management, shipping and payables. The firm was able to reduce inventory shrinkage and OOS conditions due to the adoption of automatic product tracking practices and thereby reduce errors in data entry process. Hence it is concluded from the case study that implementation
of the RFID system does not result in inaccuracy in inventory management for
normal business operations. Reduction of unproductive inventory and POS systems
are the result of implementation of RFID and practices related to integration of RFID
in VMI programs.

It is also identified from the previous section that implementation of RFID in
Metro Group has impacts on inventory management and also considerably reduced
the level of inventory inaccuracies. It can be argued that in Metro, RFID is
implemented in an innovative manner. RFID is implemented for both the warehouse
and store levels. Pallets and cases that are delivered from Metro Group Distribution
Logistics warehouse are attached with RFID tags. The flow of goods is then recorded
or tracked by the RFID readers that are integrated at the exit or entry gates and zones
of warehouses and stores.

Metro implements the RFID system in actual shelves that store the goods that
are to be delivered or sold which is a very effective measure not seen in Wal-Mart
stores thereby giving Metro an edge. The shelves are known as Smart Shelves which
includes an RFID reader that automatically tracks the products placed on it. The firm
also makes efforts to implement an RFID system on pallets and case level tracking.
The practice of automatic self-check outs is considered general practice in shopping
activities in Rheinberg. It is also argued that the majority of the customers made use
of the system at least once for making payments for their purchases.

Tracking of products during transportation is not provided by the conventional
and traditional systems. At the same time the RFID system enables the firm to track
the products in the entire SC. Hence the firm is provided with the benefit of making
early decisions with respect to inventory control when there are certain interruptions
in the SC. Such practice may reduce or eliminate the efforts and time invested for
counting the number of products during loading or unloading, thereby reducing the
total lead-time for arrival of the order. RFID can be implemented by retail industries
in order to decrease the lead times and promote the total useful shelf life of goods.

6.3.2 Information sharing

Another important performance measure which needs to be examined is the
degree of information sharing. Wal-Mart is able to provide support for buyers, and
promote the accuracy of purchasing forecasts by means of combining sales data and
external information, such as weather forecasts. The firm was observed to experience
more advantages by adopting RFID since more cases and products were tagged and more data was gathered. The data collected was used for promoting replenishment with regards to improved visibility which is provided by the RFID tags by Wal-Mart and its suppliers. There were also efforts made for addressing the privacy issues and problems faced by customers with regards to national legislation and guidelines of good practices. Such practices are given more importance by Wal-Mart when compared to Metro. There are combined efforts and attempts by Gillette and MIT Auto-ID Centre to protect the privacy of consumers. The technical specifications provided by Auto-ID Centre enable the consumers to disable the RFID tags at checkout counters after purchasing the product. Wal-Mart also provides services for immobilising the RFID tracker in Gillette products before they leave the store. One very good example is in 2008. Wal-Mart examined the Gillette products integrated with RFID in order to establish a smart shelf in a store located in Brockton, Massachusetts (Kasiri et al. 2012, p. 259). It is also suggested that RFID provides flexibility for product recalls. The products that are integrated with RFID and EPC are able to determine each and every product that were sold from the store and make the recall process easier.

The major advantages which the thesis identified with respect to Metro Group are based on their practice of sharing information terminals which were firmly established by them. This shows that there is an increase in the number of consumers making use of the service, from 51% to 58%. The Information Terminals also provide information related to origin and quality of food products. The main products such as eggs, meat, fruit and vegetables are provided with such services and practices. Hence the Metro Group is considered to be the first retailer in Germany to implement such practices for customers and enable them to track the food products in accord with new EU directives.

RFID technology provides a huge amount of data for consumers and other suppliers. Based on the use of the data collected by such practices, the success factors for RFID are clear. The significant changes in the framework of the present system are recommended to make use of the data generated by such practices. The important factor to be observed with regards to the practice is the embedment of the RFID system within present information systems.
6.3.3 Cost

From the analysis of the previous section, the success of RFID implemented pull-based SC is evident with a reduction of 6.19% in overall inventory cost and an increase in overall inventory revenue by 7.6%, as described by Wal-Mart. Due to the implementation of RFID, the savings made for each dispatch note by Metro Group was estimated to be €2.84. Savings in terms of cost and time are also determined by the automation services. The cost of downstream flows of physical goods and the upstream flow of demand information is found to be reduced when there is implementation of the RFID system by the organisation.

Integrated SCM that provides product availability, inventory management and cost reduction are the major future advantages of the practice as argued by the researcher. Since 2004, the Metro Group was determined to implement In-store RFID in Future Stores. By the end of 2008, Metro Group was observed to increase the sales points in action to 200 and also included Metro Cash & Carry big supermarkets in nine central distribution warehouses. The firm also included most of the Real Warehouses and reduced overall costs by 15%.

It is also been argued by the researcher that the RFID practice has the potential for reducing labour costs by 15%. The main reason for this is the elimination of the need for an employee to scan barcodes which were printed on pallets and cases in the SC. Furthermore, it is argued that cost is reduced by 8% due to the implementation of RFID systems. Thus it can be suggested that it costs the company five cents every time a member of staff scans a barcode on a pallet in one of the warehouses; automating that process will save millions before one even begins counting benefits.
CHAPTER SEVEN

7 CONCLUSION

7.1 Implications of the study

The main purpose for performing this study was to provide a detailed description about the impact of RFID technology on the SC performances of the world’s key retail organisations. This was achieved by providing case studies of Wal-Mart and Metro group on challenges faced by retail businesses in the retail trading industry. Through the literature review the researcher has identified key SC performance measures including cost efficiency, collaboration, integration, information sharing and inventory management. In addition, increasing cost expenditures and products cause the retailers to reduce costs and implement new IT solutions so that they may withstand competitive pressures in their businesses.

In stages, barcodes can be replaced by RFID on the basis of conditions of low price tags and hardware, international standards of common frequency of operation, accepted by numerous retailers and advancement in hardware and tag development in a number of retailing processes. RFID can also be used in warehousing, material handling, physical distribution, planning inventory control and order processing.

The introduction of new technology such as RFID in the field of retailing business helps to mark out the moving objects in the logistic networks. Both RFID as well as barcodes have their own advantages in the field of data collection and application areas. The researcher has made an inclusive comparison between RFID technology implementation in Wal-Mart and Metro regarding its reading range and rate, read/write operations, identification, interference, improved efficiency in warehousing, cost performance and automation along with the incorporation of reading rates, data capacity, communication protocols, cost, and so on.

RFID can be used by various large retailer corporations such as Wal-Mart, as an electronic code to modernise the SC process. For example, Wal-Mart requests its suppliers to tag each and every pallet of products in the warehouse. The advent of smart shelf indicates to the employees the need to replenish products immediately as they reach an OOS condition. Such an invention assists in reducing the faults between inventory records and the physical records so that there is a significant improvement in the effectiveness of inventory management. The implementation of RFID in the progression of material handling equipment will increase the efficacy of...
picking process by up to 15–20 %. In contrast, the implementation of RFID for POS’s can effectively reduce the time taken by a cashier and reduce the tail-back time. Eventually, RFID must be developed in a way such that strategic implementation is concerned with data management, system integration and security.

Generally, the logistic operation can be executed by managers as they make decisions on their knowledge of business logistics. In line with this statement, it is evident that the performance of logistic operations can be influenced by the decisions of managers, but this is very rare in practice. In this study, RFID implementation in retailing presents future trends for the development of a real-time knowledge-based system that has been used to support the performance of logistic processes by means of assimilating the decisions of workers with the help of agent technology along with RFID technology within the logistic operation settings.

Amalgamation of retail logistic operations with RFID technology will enhance the operational efficiency and functioning of logistic process within the retail industries. The researcher suggests that other hypermarkets and supermarkets should adopt the trends established by Wal-Mart and Metro Group and try to implement RFID technology in their logistics operations. In conclusion the researcher would like to indicate the importance of RFID technology in terms of three important contributions to operational processes:

1. The implementation of RFID technology helps to perform the operational process as well as resource visualisation;
2. The integration of multi-agent technology to the enterprise database helps in the delivery of correct logistic procedure and logistic process at the ideal time in retail industries;
3. The achievement of effective resource allocation and process management, for which it is essential to adopt a real-time knowledge-based system.

7.2 Limitations

This study did not adopt a primary data collection approach. Secondary data while useful presents a historic view of the topic. Collection of primary data in future research will play a vital role in presenting a more real-time representation of the current conditions of RFID implementation. Efforts can be taken to examine challenges, barriers and advantages to the implementation of RFID.
7.3 Future research

This study was primarily conducted from a case study perspective where only two organisations were chosen as the research organisations. For the results to be applicable in Europe and America there is a need for studies to be conducted in other organisations. The researcher indicates that future research can compare 3–4 case study organisations from both the countries (intra- and inter-country) and their differences in order to arrive at clearer recommendations.
8 REFERENCES


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9 APPENDIX

APPENDIX A1 BARCODE TECHNOLOGY

The Barcode system has many advantages with regard to manual handling. These include data accuracy, data transfer speed and flexibility. On the other hand, the Barcode system also has several disadvantages, such as:

- Each item - either a single product or a batch or truck - must be manually scanned. Many attempts have been made to automate scanning procedures, with mixed results.
- Barcodes can store only a limited amount of information.
- When a tag is printed, the information contained in the tag cannot be changed. New information requires a new tag.
- Harsh environments can also damage the tag so that it cannot be read by a scanner (Rundh 2008, p. 98).
APPENDIX A2 RFID HISTORY

While RFID has been of great interest to researchers in the current years, it first came into existence in the Second World War, when aircraft were identified as friend or foe using this technology (Ton et al. 2009, p. 2). The optical barcode, which is the closest rival of RFID, came into commercial usage in the 1960s and 1970s (Karmakar 2010, p. 15). Due to its inexpensive implementation and benefits over modern technologies, the barcode was a great success and is still used commonly in almost everything today. However, since the late 1970s, increases in the complexity and size of businesses have led to the need for new technology. This led to the journey towards RFID. In 1948, Harry Stockman first demonstrated communication through reflected power, and in 1950 the first patent was taken out for the passive tags. Until 1979, research related to RFID remained in laboratory settings. Early commercial usage included animal tracking in the US. This was followed by vehicle toll collection in Norway in 1987, followed in 1994 by RFID tracking of US railcars (Karmakar 2010, p. 15). In 2004, The American Express Blue credit card started including a feature called Express Pay that used RFID technology to authenticate the cardholder, and in the same year Toyota Company introduced RFID-enabled keys in certain Lexus models. In 2005 and beyond the use of RFID continued to expand (Ton et al. 2009, p. 2).
APPENDIX A3 EPC SYSTEM RFID TAG CLASSES

The table below gives more information about EPC system RFID tag classes

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 0</td>
<td>The simplest of tags with the main functionality to offer electronic article surveillance (EAS). The tags in this class are passive.</td>
</tr>
<tr>
<td>Class 1</td>
<td>These tags contain the unique identifying data stored on write once read many (WORM) memories. They are usually passive tags, and are simple identifiers with little logic.</td>
</tr>
<tr>
<td>Class 2</td>
<td>Have read and write capabilities and can thus be recycled and used to identify different items until destroyed. The tags in this class are passive.</td>
</tr>
<tr>
<td>Class 3</td>
<td>Data is stored in read and write many memories. Contains an onboard battery that is used to enhance the transmitting range. The tags in this class are semi passive.</td>
</tr>
<tr>
<td>Class 4</td>
<td>Have read and write memory capabilities as well as an active transmitter for initiating communication. The tags in this class are active.</td>
</tr>
</tbody>
</table>

EPC system RFID tag classes
(Muwanguzi & Biermann 2010, p. 201)
APPENDIX A4 RFID TAGS

1- Active Tag

When active tag communicates with the reader, it is the first unit to be engaged in data transmission. Because the presence of the reader is not necessary for data transmission from the tag, an active tag can transmit data continuously without the presence of a reader. This method of communication between the reader and the tag is known as transponder-driven. Although the active tag has an on-board power supply, additional techniques to extend the battery life through low-power consumption have been implemented in the form of sleep modes. Active tags that do not detect the interrogation zone of a reader hibernate by going into a sleep mode, and thus do not waste power (Kossel et al. 1999, p. 2242). The most important feature is that active RFID tags are reprogrammable. As a result, active tags can be used on a variety of items repetitively until the battery power is exhausted.

2- Semi-Active Tag

When a semi-active tag is communicating with the reader, the tag must first recognise the interrogation signal of the reader in order to reply. This communication protocol is known as interrogator-driven. Some semi-active tags can still perform complex tasks like data processing and encryption, and can reach a reading range almost as large as active tags. These advantages can be exploited with the advent of the very-low-powered, highly efficient microprocessors available in the market today (Preradovic et al. 2008, p. 93).

3- Passive Tag

The RF front end of the passive tag consists of the antenna and the impedance-matching circuit in order to reduce the reflection of the signal between the antenna and transponder circuit. The analogue part of the passive tag may comprise an LC-tuning circuit and a rectifier (Ghovanloo & Najafi 2004, p. 1978). The rectifier supplies the required direct current voltage to the digital circuit (Preradovic et al. 2008, p. 93). The digital circuit of passive tag is completely optional and may have an IC, an Application Specific Integrated Circuit (ASIC) or just a memory block of a few Kilo-Bits (Preradovic et al. 2008, p. 93). Most passive tags have precisely designed microchips and ICs that contain digital logic sectors, which process data rapidly.

The most important advantages of passive tags are low cost and low maintenance (Kasiri et al. 2012, p. 256). Based on these most important features,
passive tags are used in a wide range of applications such as medical, SCM and wireless sensing (Philipose et al. 2005, p. 38).
APPENDIX A5 RFID FREQUENCIES

1- High Frequency (HF)

High frequency tags can be easily read while attached to objects containing water, tissues, metal, wood and liquids. However, the performance of HF tags is affected by close proximity to metal objects. The higher data transfer rate of HF tags, along with their limited read range, makes these systems an ideal choice for applications such as credit cards and smart cards. Due to those properties, HF tags are currently the most widely used RFID tags around the world (Lin 2009, p. 833).

2- Ultra-High Frequency (UHF)

The performance of UHF is severely degraded when attached to objects containing water, biological tissues and metals. The proximity of those materials will degrade the efficiency of the tag through absorption and detuning. The range will also be affected by propagation effects in unfavourable environments. UHF tags cannot be read if water or any conductive material is placed between the interrogator antenna and the tags (Lin 2009, p. 833).
APPENDIX A6 THE CURRENT ISSUES FACING RFID TECHNOLOGY

1- Security and privacy

RFID technology has proven to be reliable, especially in SC and is already showing great advantages. But an automated SC mandates the necessity for data privacy, identity and non-refutability and organisations should ensure the RFID technology they adopt supports their security requirements. Companies need to be aware of the security risks, such as profiling, eavesdropping, denial of service attacks and inventory jamming (Ngai & Gunasekaran 2009, p. 3).

RFID has the potential to threaten consumers through intervention of their informational privacy, their physical privacy and security and their civil liberties (Ngai & Gunasekaran 2009, p. 3). Consumers are concerned with the possible abuse of personally identifiable data (such as credit card number and security number) and sensitive data (such as prescription drugs) by retailers when companies adopt RFID technology. A considerable driver of consumers’ fear of RFID is a lack of understanding about the RFID technology. Companies should inform consumers that they use RFID tags on their products and educate consumers of the true technological limitations of RFID.

2- Quality assurance

An important part of the user’s requirement is that the tags on all goods must be intact and readable. Consider Wal-Mart as an example - pallet tags must be 100% readable at the receiving dock and case tags must be 100% readable on a conveyor moving at the speed of 600 feet per minute with a minimum spacing of 8 inches between cases (Ngai & Gunasekaran 2009, p. 4).

One should ensure that there are sufficient processes, checks and balances in place to guarantee that all RFID tags on pallets/cases have been written correctly and are intact at the point of shipment to the next location, whether this be a customer location or another distribution centre. One should also ensure that all reasonable steps have been taken to prevent the damage or removal of the tag in transit.

3- Cost challenges

The biggest challenge companies faced with RFID is the high cost of implementation. One of the challenges a company faces with the introduction of RFID technology is whether the business really needs the technology, and how to justify the investment in the implementation. Cost-benefit analysis is critical to the successful adoption of an RFID project. At present, the cost of RFID adoption is the
major investment in hardware, application software, middleware and tags, and the cost of integrating the RFID-based system with the legacy systems, consultancy fees and employee training. However, different cost sharing schemes can be used to encourage companies to adopt RFID in an SC (Ngai & Gunasekaran 2009, p. 5).
## APPENDIX A7 COMPARISON BETWEEN RFID AND BARCODE

Table below illustrates the comparison of RFID and Barcode based upon some characteristics (Mehrjerdi 2011, p. 256).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>RFID</th>
<th>Bar code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read rate</td>
<td>Many tags can be read simultaneously-high productivity.</td>
<td>Read one tag at a time and manually.</td>
</tr>
<tr>
<td>Read range</td>
<td>Passive RFID: Up to 25 feet</td>
<td>Several inches up to several feet</td>
</tr>
<tr>
<td></td>
<td>Active RFID: Up to 100’s of feet or more</td>
<td></td>
</tr>
<tr>
<td>Reading capability</td>
<td>Requires energy path but not line of sight</td>
<td>Requires line of sight</td>
</tr>
<tr>
<td>Identification</td>
<td>Can uniquely identify each item/asset tagged</td>
<td>Can typically only identify the type of item (UPC Code) but not uniquely</td>
</tr>
<tr>
<td>Data transmission</td>
<td>Radio Frequency (Electromagnetic wireless)</td>
<td>Optical (Laser)</td>
</tr>
<tr>
<td>Human capital</td>
<td>Once system is designed and set up then it is completely automated and does not need too much human help.</td>
<td>Needs human capital to scan each tag.</td>
</tr>
<tr>
<td>Data modification</td>
<td>Ability to read, write, modify, and update.</td>
<td>Ability to read and only write once</td>
</tr>
<tr>
<td>Durability</td>
<td>High-it can be used in harsh environments.</td>
<td>Low-it cannot use when it is dirty or greasy.</td>
</tr>
<tr>
<td>Tag/Label cost</td>
<td>Depends upon tag type</td>
<td>Very low</td>
</tr>
<tr>
<td>Anti-collision</td>
<td>Yes - Depends upon protocol used but most have anti-collision</td>
<td>Not applicable since read is linear</td>
</tr>
<tr>
<td>Data capacity</td>
<td>1 bit - Megabytes</td>
<td>≤ 100 bytes</td>
</tr>
<tr>
<td>Access security</td>
<td>Can be high</td>
<td>Low, possible if barcode hidden</td>
</tr>
<tr>
<td>Event triggering</td>
<td>Capable to trigger certain events.</td>
<td>Not capable of triggering events</td>
</tr>
</tbody>
</table>

Comparison of RFID and Barcode
APPENDIX A8 METRO GROUP SALES BRANDS

Metro Group offers private and commercial customers a broad array of services in cash and carry, and also in retail. With their specific offers designed to meet the growing demands of customers, Metro Group’s sales brands have become individual retail brands in many ways. They continuously fine-tune their sales concepts with the aim of convincing customers of the value of their service offerings and, as a result, solidifying the foundation of their future business success.

1- METRO CASH & CARRY

Metro Cash & Carry was founded in Germany in 1964. It is the world’s leading player in the cash and carry sector. The company quickly spread into 740 different locations in 30 countries throughout Europe, Asia and Africa. The wholesale stores offer products and services tailored to specific needs of commercial customers, such as hotel and restaurant operators, catering firms, independent retailers, service providers and public authorities (Metro Group 2011 Annual Report, p. 91).

2- REAL

Real has been one of the leading hypermarket operators in Germany since 1992. It runs both stationary stores and an online store. In addition, the sales division has around 425 different locations in 6 countries. Real is a stand for a multifaceted range of food products offering a great price-performance ratio with a large share of fresh produce complemented by an attractive non-food assortment (Metro Group 2011 Annual Report, p. 91).

3- MEDIA MARKT

Media Market is the German and European market leader in consumer electronics retailing. The sales division is represented in 657 different locations in 16 countries. The Media Market brand is synonymous with providing a comprehensive assortment in the fields of consumer electronics, telecommunications, photography, entertainment, computers, software and household appliances. A wide range of services and competent, individual customer advice characterises the service standard (Metro Group 2011 Annual Report, p. 91).

4- SATURN

Within Metro Group, Saturn embodies the concept of consumer electronics stores established mostly in central downtown locations with an extraordinarily wide assortment. The sales division is represented in 239 different locations in 16 countries. Saturn comprises up to 100,000 products from the fields of consumer...
electronics, household appliances, new media, telecommunications, computers and photography. Permanent low prices in all assortment areas represent an additional competitive advantage of the Saturn stores (Metro Group 2011 Annual Report, p. 91).

5- **GALERIA KAUFHOF**

Galeria Kaufhof is one of Europe’s leading department stores operated by Metro Group. The sales division is represented in 141 different locations in 2 countries. Its stores are characterised by high performance, international assortments and top quality own brands, as well as an event-orientated product presentation. The stationary business is closely dovetailed with the online store (Metro Group 2011 Annual Report, p. 91).

6- **METRO PROPERTIES**

Metro Properties is Metro Group’s real estate company. Its portfolio comprises 687 retail properties as well as 153 trade-related real estate assets. The Company aims to add value to the Group’s real estate assets through active portfolio management. Its activities include planning new locations, development and construction of retail properties and energy management on behalf of Metro Group locations (Metro Group 2011 Annual Report, p. 91).

Table below describes the 2011 Metro Group sales brands operating segments.

<table>
<thead>
<tr>
<th>In 2011</th>
<th>Sales</th>
<th>EBITDA</th>
<th>Locations</th>
<th>Countries</th>
<th>Selling Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>METRO CASH &amp; CARRY</td>
<td>31,176</td>
<td>1,297</td>
<td>740</td>
<td>30</td>
<td>5,517</td>
</tr>
<tr>
<td>REAL</td>
<td>11,231</td>
<td>292</td>
<td>425</td>
<td>6</td>
<td>3,082</td>
</tr>
<tr>
<td>MEDIA + SATURN</td>
<td>20,604</td>
<td>767</td>
<td>896</td>
<td>16</td>
<td>2,880</td>
</tr>
<tr>
<td>GALERIA KAUFHOF</td>
<td>3,450</td>
<td>193</td>
<td>141</td>
<td>2</td>
<td>1,475</td>
</tr>
</tbody>
</table>

(Metro Group 2011 Annual Report, p. 184)
## APPENDIX A9 METRO’S FINANCIAL STATEMENTS

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Net sales</strong></td>
<td>€67,258</td>
<td>€66,702</td>
</tr>
<tr>
<td><strong>Cost of sales</strong></td>
<td>-52,865</td>
<td>-52,700</td>
</tr>
<tr>
<td><strong>Gross profit on sales</strong></td>
<td>14,393</td>
<td>14,002</td>
</tr>
<tr>
<td>Other operating income</td>
<td>1,627</td>
<td>1,690</td>
</tr>
<tr>
<td><strong>Selling expenses</strong></td>
<td>-12,173</td>
<td>-11,928</td>
</tr>
<tr>
<td>General administrative expenses</td>
<td>-1,585</td>
<td>-1,587</td>
</tr>
<tr>
<td>Other operating expenses</td>
<td>-51</td>
<td>-64</td>
</tr>
<tr>
<td><strong>Earnings before interest and taxes EBIT</strong></td>
<td>2,211</td>
<td>2,113</td>
</tr>
<tr>
<td>Result from associated companies</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other investment result</td>
<td>15</td>
<td>41</td>
</tr>
<tr>
<td><strong>Interest income</strong></td>
<td>112</td>
<td>133</td>
</tr>
<tr>
<td>Interest expenses</td>
<td>-718</td>
<td>-713</td>
</tr>
<tr>
<td>Other financial result</td>
<td>10</td>
<td>-102</td>
</tr>
<tr>
<td><strong>Net financial result</strong></td>
<td>-581</td>
<td>-640</td>
</tr>
<tr>
<td><strong>Earnings before taxes EBT</strong></td>
<td>1,630</td>
<td>1,473</td>
</tr>
<tr>
<td>Income taxes</td>
<td>-694</td>
<td>-732</td>
</tr>
<tr>
<td><strong>Net profit for the period</strong></td>
<td>936</td>
<td>741</td>
</tr>
<tr>
<td>Net profit attributable to non-controlling interests</td>
<td>86</td>
<td>110</td>
</tr>
<tr>
<td>Net profit attributable to shareholders of METRO</td>
<td>850</td>
<td>631</td>
</tr>
<tr>
<td><strong>Earnings per share</strong></td>
<td>2.60</td>
<td>1.93</td>
</tr>
</tbody>
</table>

(Metro Group Annual Report 2011)
APPENDIX A10 MOBILE SHOPPING

One of the most important innovations at the Future Store is the Mobile Shopping Assistant (MSA). This is an application for mobile phones that allows customers to scan their purchases while shopping. The MSA makes long queues at the checkouts a thing of the past. ‘Almost every consumer these days owns a mobile phone and uses it as a matter of course’, argues Dr. Cordes. ‘Today’s high-performance mobile phones are ideally suited for mobile shopping’. The MSA was developed in collaboration with Deutsche Telekom. Customers use their device to find specific products in the store or to call up product information (Metro Group Future Store 2010).
APPENDIX A11 INNOVATIVE TECHNOLOGIES AND NEW CHECKOUT SYSTEMS

Even greater convenience is provided by the state-of-the-art payment options for instance, the new pay by:

1- **Fingerprint system:**
   
   With this system, customers only need to place their finger onto a specially developed fingerprint scanner to pay for their purchases - without the need for any signature or PIN. Modern encryption algorithms make this an extremely secure method of payment (Metro Group Future Store 2010).

2- **Smart Checkout systems:**

   The Future Store trialled a variety checkout systems. These included check out through the Personal Shopping Assistant (PSA) as well as self-checkout.

   - **Personal Shopping Assistant (PSA):**
     
     PSA is a handheld device similar to a tablet PC that shows the customer an electronic shopping list after they scan the products via the integrated barcode scanner. The PSA automatically sums up the total price of goods scanned at any given time as well as the total savings through discounts. When the customer reaches the checkout, their PSA transmits the shopping information directly to the POS. This innovation is under modification to take RFID application by replacing the barcodes with RFID tags.

     The benefit of the PSA method is that once the customers enter the checkout area, the data from the PSA server is transferred automatically to the checkout such that the customers never needs to unload and then reload their carts (Metro Group Future Store 2010).

   - **Self-Checkout**
     
     The self-checkout process involves the customer scanning the products themselves without a cashier, in an Automatic Fast Lane. The self-checkout is performed using easy-to-use touch screens and payment terminals. The customer pays either through cash, debit card or credit, just as in a standard ATM machine. The verification that the customer has correctly paid for the purchased goods is automatically achieved by comparing the weight of the shopping bags that the scanned products are placed into by the customer with that of the total weight of goods registered in the scanner. If there is any discrepancy, the system alerts a store employee (Metro Group Future Store 2010).
APPENDIX A12 COMFORT SHOPPING

The following are the innovations tested as part of the comfort shopping program:

- **Electronic Advertising Displays:**

  Electronic Advertising Displays in the Future Store show video footage about products and special offers. The footage is shown on a big plasma screen and the footage clips are sent from a database via WLAN. A central control point allows almost instant control of the contents shown on the Electronic Advertising Displays (Metro Group Future Store 2010).

- **Intelligent scale:**

  An ‘intelligent’ weighing scale is used to automatically recognise the fruits or vegetables gathered by the customer without requiring the customer or employee to select the chosen item on a screen. The intelligent scale works using a camera and advanced identification software to determine the gathered item from its shape, colour, surface, size, etc. The customer is only required to confirm that the Intelligent Scale has correctly identified the product. It is anticipated that in the future, the Intelligent Scale will not only be used to weigh fruits and vegetables, but also to weigh meat, fish and cheese (Metro Group Future Store 2010).

- **Electronic Price Labels:**

  RFID tags placed on products and electronic price labels on shelves enable product prices to always be accurately displayed and updated. The updating of prices is performed centrally by the store’s computerised merchandise management system and then passed by radio frequencies to the RFID tags and price labels. This ensures that the displayed price is always the same as that registered at checkout. The electronic labels consist of a small battery, a tiny antenna, a receiver and display elements. Battery power is only required to modify individual display elements when altering a displayed price, and thus saves the service life of the battery, which is about five years or more (Metro Group Future Store 2010).
APPENDIX A13 METRO GROUP LOGISTICS (MGL)

The range of products handled by MGL’s warehouses and platforms in Germany comprises some 20,000 different items in the categories of fresh, frozen and dry foods, and several hundred items in the categories of fruits, vegetables and non-food items. In addition to its standardised solutions for procurement, warehousing and distribution logistics, MGL offers customised extended logistics services such as the worldwide selection and purchase of fresh fruits, vegetables and plants, international transport networks, import and export related services and consultancy with regard to optimised logistics structures and SC processes.

The logistics company of Metro Group consists of two legal entities with about 3,300 employees. The entity MGL Warehousing is registered in Sarstedt and is responsible for MGL’s warehousing and distribution activities in Germany. The entity MGL, located in Düsseldorf, provides the procurement logistics systems in Germany, Austria and Switzerland and manages all international logistics services of MGL (Metro Group 2011).
## APPENDIX A14 WAL-MART’S FINANCIAL STATEMENTS

<table>
<thead>
<tr>
<th>$ million</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating Results</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net sales</td>
<td>$405,132</td>
<td>$418,952</td>
</tr>
<tr>
<td>Net sales increase</td>
<td>1.0%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Comparable sales in the United States</td>
<td>-0.8%</td>
<td>-0.6%</td>
</tr>
<tr>
<td>Wal-Mart U.S.</td>
<td>-0.7%</td>
<td>-1.5%</td>
</tr>
<tr>
<td>Sam’s Club</td>
<td>-1.4%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Gross profit margin</td>
<td>24.9%</td>
<td>24.7%</td>
</tr>
<tr>
<td>Operating, selling, general and administrative expenses, as a percentage of net sales</td>
<td>19.7%</td>
<td>19.3%</td>
</tr>
<tr>
<td>Operating income</td>
<td>$24,002</td>
<td>$25,542</td>
</tr>
<tr>
<td>Income from continuing operations attributable to Wal-Mart</td>
<td>14,449</td>
<td>15,355</td>
</tr>
<tr>
<td>Net income per share of common stock: Diluted net income per common share from continuing operations attributable to Wal-Mart</td>
<td>$3.73</td>
<td>$4.18</td>
</tr>
<tr>
<td>Dividends declared per common share</td>
<td>1.09</td>
<td>1.21</td>
</tr>
<tr>
<td><strong>Financial Position</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inventories</td>
<td>$32,713</td>
<td>$36,318</td>
</tr>
<tr>
<td>Property, equipment and capital lease assets, net</td>
<td>102,307</td>
<td>107,878</td>
</tr>
<tr>
<td>Total assets</td>
<td>170,407</td>
<td>180,663</td>
</tr>
<tr>
<td>Long-term debt, including obligations under capital leases</td>
<td>36,401</td>
<td>43,842</td>
</tr>
<tr>
<td>Total Wal-Mart shareholders’ equity</td>
<td>70,468</td>
<td>68,542</td>
</tr>
</tbody>
</table>

(Wal-Mart 2011 Annual Report)
APPENDIX A15 WAL-MART OPERATIONS BUSINESS SEGMENTS

Wal-Mart’s operations are comprised of three business segments:

1- Wal-Mart Stores Segment:

This is the largest segment, which accounted for approximately 62.1% of their 2011 fiscal sales. This segment consists of four different retail formats, all of which are located in the United States. These include the following sections:

• Wal-Mart Supercentres
  Wal-Mart Supercenters were developed in 1988 to meet the growing demand of convenient stores. There are 3,029 Supercenters nationwide, and most are open 24/7. A Supercenter’s average size is approximately 185,000 square feet, and it offers a wide variety of products (Wal-Mart Stores 2012).

• Wal-Mart Discount Stores
  In 1962, Sam Walton opened the first Wal-Mart discount store. Today, there are around 624 stores offering a pleasant and convenient shopping experience across the United States. The size of the average store is approximately 108,000 square feet. Each store offers a wide variety of products (Wal-Mart Stores 2012).

• Wal-Mart Neighborhood Markets
  In 1998, Wal-Mart opened the first Neighborhood Market. Today, there are around 199 such markets offering a quick and convenient shopping experience for customers who need groceries, pharmaceuticals, and general products, all at ‘Everyday Low Prices’. The size of an average market is approximately 42,000 square feet (Wal-Mart Stores 2012).

• Wal-Mart Express Stores
  In 2011, Wal-Mart opened the first two Express test stores in Northwest Arkansas. Wal-Mart has created Express test stores to offer low prices every day in a smaller format store that provides convenient access for fill-in and stock-up shopping trips. The stores give Wal-Mart flexibility in serving customers, especially in rural and urban areas where shoppers may not have access to larger stores. The size of an average Express test stores is approximately 15,000 square feet, and these stores offer groceries and general products (Wal-Mart Stores 2012).

2- Sam’s Club Segment

In 1983, Sam’s Club opened its doors in Midwest City, Oklahoma. Today, Sam’s Club operates around 609 locations nationwide. It accounted for
approximately 11.8% of 2011 fiscal sales (Wal-Mart 2011 Annual Report, p.17). Also, Sam’s Club has more than 100 international Sam’s Clubs in Brazil, China, Mexico and Puerto Rico (Wal-Mart Stores 2012).

3- Wal-Mart International Operations

International Operations are located in Argentina, Canada, Germany, South Korea, Puerto Rico and the United Kingdom, with joint ventures in China and operations of majority - owned subsidiaries in Brazil and Mexico. This segment generated approximately 26.1% of 2011 fiscal sales (Wal-Mart 2011 Annual Report, p. 17). International Operations operates several different formats of retail stores and restaurants, including Supercenters, Discount Stores and Sam’s Clubs (Wal-Mart Stores 2012).

Table below demonstrates the 2011 Wal-Mart operating segments.

<table>
<thead>
<tr>
<th></th>
<th>In 2011</th>
<th>Sales</th>
<th>Operating income</th>
<th>Unit counts</th>
<th>Retail (sf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wal-Mart US</td>
<td>$260,261</td>
<td>$19,914</td>
<td>3,854</td>
<td>617,067</td>
<td></td>
</tr>
<tr>
<td>Wal-Mart International</td>
<td>$109,232</td>
<td>$5,606</td>
<td>4,557</td>
<td>286,680</td>
<td></td>
</tr>
<tr>
<td>Sam’s Club</td>
<td>$49,459</td>
<td>$1,711</td>
<td>609</td>
<td>81,202</td>
<td></td>
</tr>
</tbody>
</table>

(Wal-Mart 2011 Annual Report, pp. 21-22)

The following figure illustrates the 2011 sales of Wal-Mart operating segments

![Wal-Mart Sales by Segment (in billion)](image1)

(Wal-Mart 2011 Annual Report, p. 2)

Figure below also demonstrates the 2011 percent of total Wal-Mart’s segments

![Percent of Total Wal-Mart’s Segments](image2)

(Wal-Mart 2011 Annual Report, p. 17)