

Defining KPIs from the TEB model for RFID in the supply chain management area in Greece

Vasilia P. Peppas & Socrates J. Moschuris

University of Piraeus
Piraeus-Athens, Greece

ABSTRACT: This article presents information regarding the key performance indicators (KPIs) for radio frequency identification (RFID) technology from the TEB (technology - education - business) model. Indicators will be adopted in the supply chain management area in Greece. The article examines the key performance indicators from the three different systems (technology, education and business); and an extended analysis focusing on the adoption of the RFID technology in the Greek environment is also included. A sample of 52 filled-in questionnaires from Greek companies in the supply chain management area provided the data that were analysed and adopted to the TEB model's key performance indicators. Furthermore, the impact and the results originated from KPIs for the RFID technology in these companies are critically evaluated.

INTRODUCTION

Measurement of performance reflects the critical success factors of an organisation, school, government, etc. Key performance indicators (KPIs) differ from one company to another. For example, a company may have as one of its key performance indicators the income from its sales. Schools or universities may have the success of their students in gaining employment in different areas or industries after graduation and governments may have the income from the taxes that citizens pay. Key performance indicators should reflect an organisation's goals and be considered as long term goals for the efficiency of the organisation. The role of these measures and metrics in the success of an organisation cannot be overstated because they affect strategic, tactical, and operational planning and control [1].

Performance measures help businesses to align activities to improve their strategy and to gain a competitive advantage in the global market. Furthermore, KPIs can give a clear picture to organisations of what is important and critical for the effectiveness of the organisation. Everyone from inside the organisation can focus on these indicators and be motivated in order to reach the key performance targets. Performance measures should be based on a set of objectives that are connected to the mission of the organisation and its visions for the future [2]. Performance measures can be defined as *...the numerical or quantitative indicators that show how well each objective is being met* [3]. Other authors have defined performance measure as *...a parameter used to quantify the efficiency and/or effectiveness of past action* [4]. Finally, using KPIs for performance measurement is critical for companies aspiring to improve the effectiveness and efficiency of the supply chains, and managers have to identify the critical KPIs in order for them to come up with improvements [5][6].

It is worth noting that the TEB (technology - education - business) model that was introduced can help businesses, organisations, universities and governments to define their key performance indicators and focus on specific targets on which each of them can focus [7]. From the above model, the authors have derived the more important key performance indicators for the supply chain management area and more specifically in Greece.

Radio frequency identification technology (RFID) has been identified as one of the greatest new technologies of the 21st Century [8]. Supply chain management technology is very important and is considered to be the next revolution as this technology can track each object in real time through the supply chain [9].

PROBLEM STATEMENT AND SIGNIFICANCE OF THE STUDY

A vast number of studies in the literature have shown the importance of radio frequency identification technology in the area of supply chain management. This specific technology can improve companies' effectiveness and competitive advantage. The implementation of such innovative technologies has shown that it can affect the way businesses are run

and also lead to the reorganisation of the whole supply chain. KPIs need to be identified by those who are involved through the supply chain area. The identification of such indicators will lead companies to become more successful, competitive and to be strong market players.

This article will contribute to knowledge in the following areas: 1) identification and analysis of key performance indicators from the TEB model; 2) focus on the RFID technology system, education system and business strategy; 3) the use of these key performance indicators in the supply chain management area in Greece; and finally, 4) reflection on the results and lessons learned from the whole research.

INTRODUCTION TO THE TEB (TECHNOLOGY - EDUCATION - BUSINESS) MODEL

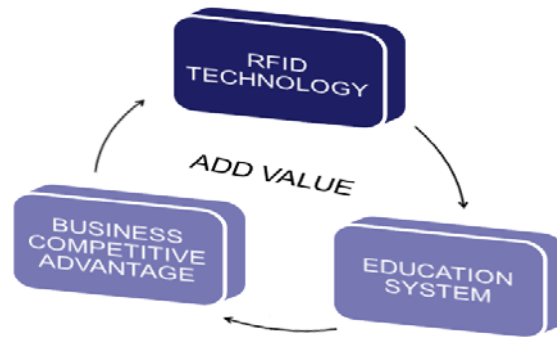


Figure 1: Three models collaboration.

The above model was derived from interviews conducted in enterprises from a range of industries. It is focused on the RFID technology and its adoption to these specific enterprises. In order to add value in the future and to make enterprises more competitive, the RFID technology needs to be integrated into the education system and, therefore, educated students and professionals will collaborate together for the best business strategy for future enterprises. Enterprises can fully support RFID systems with their existing systems and, therefore, automate all their internal and external procedures. Some of the main points that the above model introduced can be related to engineering and technology education and innovation. Engineering academics could focus on such technologies and create new problem solving methods that will help all businesses to stay competitive in the global market. Models, process models or meta-models could be developed in order to produce a comprehensive analysis of the framework of the RFID technology and supply chain management. Furthermore, new and innovative applications could also be developed for better integration between the RFID technology and supply chain applications. New implementations, skills and methods could also be used in order to act as a strong weapon for all businesses to gain a competitive advantage.

Academics play a fundamental role through this system as they give valuable knowledge and skills to students in order to increase their professional potential. Successful training processes could be achieved by engineering professionals' visits to universities that would provide students with the opportunity to work on the RFID technology practical activities and, therefore, realise professional work. The RFID technology can be included in a range of practices in schools and universities by developing an RFID laboratory that could help all students gain experience.

The identification and analysis of the KPIs accomplishes the connection between the three systems that are included in the TEB model. KPIs will also add value to businesses, education and technology.

IDENTIFY KPIs FROM RFID TECHNOLOGY MODEL IN THE AREA OF SUPPLY CHAIN MANAGEMENT

The authors identified the main KPIs for the three systems separately. These were collected from 52 answered questionnaires from companies in the area of supply chain management. A *performance metric* can be defined as the scope, content and component parts of a broadly-based performance measure [4]. RFID has been related to the technology itself [10] and innovation management [11]. RFID technological innovation had focused on tag innovation and automation, manufacturing automation, logistical control and e-commerce applications [8]. Such technology can be applied to track successfully all kinds of goods within the supply chain.

As the RFID technology is fully integrated with application packages, such as ERP (enterprise resource planning), SCM (supply chain management), CRM (customer relationship management) and BI (business intelligence), it is worth mentioning that these KPIs are related to the whole supply chain. Unfortunately, most companies are ignoring the importance of analysing KPIs and they stop measuring and reporting them. As a result, they have not understood and realised what went wrong in different situations [12]. The authors collected information about some of the major key performance indicators from the questionnaires and some from interviews.

Cost: improvements in performance were critical for most of the companies. Visibility of their inventory would be the most important task as it could lead the companies to establishing a competitive advantage and efficiency within their

production line. RFID installation cost, distribution cost, inventory cost, manufacturing cost, procurement cost, tracking cost, total stock cost, turnover cost, information management costs, warranty costs were of great importance. The measurable cost across the whole supply chain is critical and important. For example, the inventory turnover key performance indicator measures the time it would take a company to sell its entire inventory. It is better for the company to have a higher turnover rate because with a lower rate it is difficult for the company to turn its stock into revenue. An inventory accuracy key performance indicator can check the inventory and the items that the company has in stock and compare them with the recorded database from the company's ERP application. The running cost of inventory is also critical because it measures the cost of storing the inventory of a company for a specific period of time. It is also important for companies that are determined to lower supply chain costs and to align with a strategy of low cost provision.

Value: delivering value is very difficult, but the companies that manage to deliver the best value to their customers and to the company itself are the most successful. In such situations, the key performance indicators are focussed on areas that add value. New technology innovations, such as RFID can add value to customer service and the company's image in the global market. The value adding sometimes refers to services or products that customers are willing and prepared to pay extra for.

Efficiency/effectiveness: organisational efficiency is defined as an internal standard of performance and is approximately a construct *for doing things right* [13]. Organisational effectiveness is defined as an external standard *...of how well an organization is meeting the demands of the various groups and organizations that are concerned with its activities* [13], which is approximately a construct *for doing the right things* or having validity of outcome [14]. Efficiency and effectiveness are both measurable indicators and can be found in companies that manage assets to support demand satisfaction. Asset management of fixed and working capital can be measured and follow up the best strategy for competitive advantage. Supply chains are both efficient and effective because they add value to the whole system. Effectiveness and efficiency are correlated through strategic direction. This means that efficient supply chains are effective by definition and lead to innovations, as well as successful business goals.

Flexibility: companies need to respond quickly to marketplace changes. Through the response, companies can easily gain a competitive advantage. As far as the RFID technology is concerned, the technology itself needs to be innovative and respond to the global market demand. Supply chain response time, production flexibility, product flexibility can be measured and analysed as major key performance indicator for supply chain flexibility. Visibility systems and the RFID technology will be able to avert supply chain disruptions, reduce excess inventory, and limit substandard supply chain performance.

Reliability: reliability key performance indicators include the delivery of the correct product to the correct place and customer at the correct time with the correct packaging, quantity, documentation and without product damage. Measurable indicators are time, delivery performance and perfect order fulfilment. Reliability in the RFID technology is the correct tracking and storage of products through the distributions centres. Furthermore, the RFID technology can include the right quantity of products in stock and simultaneously through the ERP application package of the company. RFID can easily measure the status and accuracy of order tracking to the end customers. Tracking metrics are always measured in real-time. Order status metrics is a similar key performance indicator that can be measured. It tracks the real time status of all the orders from their customers.

Velocity/responsiveness: velocity refers to the time that products or services are delivered to the end customers. As key performance indicators order fulfilment lead times can be measured in order to check the exact time of the procedure of delivering the product. RFID systems can easily help this procedure by tracking the products at every stage. A response supply chain can be defined as *...a network of firms that is capable of creating wealth to its stakeholders in a competitive environment by reacting quickly and cost effectively to changing market requirements.* [15]. Three major enablers of RSC exist: value chain or a collaborative network of partners, information technology (IT) and systems, and knowledge management. The interaction between these enablers will lead to a supply chain that is responsive, competitive and flexible.

Quality: quality key performance indicators, shows how well a specific activity is undertaken. Order accuracy, picking accuracy, inventory accuracy and shipping accuracy can be measured to provide a better view of company's operations. The RFID technology can add value to quality of products or services by giving accurate metrics of where the products are placed and by giving the exact percentage of the inventory and product availability. Quality testing for products is also important, because it indicates if products are subjected to quality control measures before they enter the company from their suppliers. The procurement application from the supply chain management application package that a company operates can measure all the above indicators.

IDENTIFY KPIs FROM EDUCATION SYSTEM IN RESPECT TO RFID TECHNOLOGY

At this point of collecting key performance indicators from the education system, the authors visited higher educational institutions in Greece and interviewed professors with teaching experience in both undergraduate and postgraduate programmes. In Greece, both public and private higher educational institutions exist, but interviews were conducted

only in public institutions. As far as the number of higher educational institutions is concerned, in Greece there are 22 public universities, 14 public higher technological educational institutions and 32 private higher educational institutions for Greece and Cyprus.

In higher education institutions, the performance of academic staff is evaluated according to three major criteria: teaching, research and services [16]. Another two dimensions were added later; namely, supervision and consultancy. Performance is defined as ...a multidimensional construct and the common factors that are frequently associated with organizational performance are efficiency, quality, responsiveness, cost and overall effectiveness [17]. In order to face the challenge of competition, action needs to be taken to reform the operations of the institutions of education [18].

The following table shows the key performance indicators matrix from education in respect to the radio frequency identification technology, as it was conducted after the interviews with professors.

Table 1: KPIs from the Greek education system to the RFID technology.

Education \ RFID	Teaching	Supervision	Research	Publication	Consultation
Responsiveness	√	-	√	√	√
Cost	-	-	√	√	√
Value	√	√	√	√	√
Efficiency/effectiveness	-	√	√	√	√
Performance	√	-	√	√	√
Quality	√	√	√	√	√

Teaching: teaching innovative and new technologies, as the radio frequency identification (RFID), are a good challenge for universities and academics. The way that academics use different teaching methods depends on the responsiveness that the students have to learn new things and correspond to good marks and, therefore, be able to make some of critical evaluation. The cost to develop the RFID technology to universities does not depend on the teaching, but on the university's financials and programmes. While universities have already developed RFID technology systems for their procedures, it is easier for the lecturers/academics to teach such innovative technologies because students may see in real-time how these systems work. Teaching RFID in universities adds value to students and to the universities to follow up with technological changes. On the one hand, universities will follow a strong competitive strategy and from the other students will gain the experience and knowledge of such innovative technologies that are very important to the market. The good performance of the RFID technology will lead academics to teach such new technologies to their students. The good quality of the RFID technology plays a significant role to the teaching methods that academics use. Academics could teach all the advantages that will derive from such technologies.

Supervision: academics-supervisors oversee the performance and development of their students. Academics' role is very important as they have a kind of responsibility for their students at many levels. Apart from the teaching part they should supervise their students at many levels. In order to become effective supervisors they have to be up to date with all kinds of technological change. The RFID technology adds value to academic supervisors because they are able to teach such innovative technologies and, therefore, add value to their students as they understand the importance and see the advantages of such technologies.

Efficiency and effectiveness of the RFID technology is also very important for supervision in the education system, because it gives an advantage to supervisors who understand and teach RFID advantages, compared with other academics that do not teach innovative technologies. Quality of the RFID technology leads to the quality of supervision in the education system. Good quality of any technology gives benefits to many areas. As a result of a well-defined and well-developed innovative technology, supervisors create an independent problem-solving and learning environment for their students that is designed to help them understand such technologies, become creative and gain a small amount of experience. Hence, this experience will act as a strong tool for their future work in businesses.

Research: research in education is very important and provides universities with status. Research in education can also give valuable help to businesses as universities can undertake extended research and give results that are important to businesses. Research gathers new data from primary sources to come up with new results or for a new purpose. It is based on observable experience and/or empirical evidence. Research for the RFID technology can employ designed procedures and rigorous analysis. Furthermore, it will emphasise the development of principles or theories that will help in understanding, prediction and/or control. Academic research in the RFID technology will focus on the search for development, practical application and finding solutions to existing educational problems. While the adoption of radio frequency identification (RFID) technology is increasing, major challenges are addressed. Hence, the research in education for the RFID technology focuses on the responsiveness, cost, value, efficiency and effectiveness, performance and quality. Responsive supply chains offer real-time visibility into transactional event information, allowing quick identification of major issues. Businesses can remain nimble and responsive to shifting demand. Operations can improve performance by enabling the visibility of business activities and information data. The costs

accruing from RFID research will provide academics with the ability to implement the RFID technology in real life businesses through the supply chain.

Publication: publications derive from the research that has already been developed. All the results, conclusions, critical assessment, future prospects and evaluations that are completed through the research could be published for students, other academics and for businesses.

Consultation: consultation in education is the main link between universities/institutions and active businesses. Academics can provide students with knowledge management for the RFID technology and enable them to become valuable employees in the future. Students can gain the theoretical part, as well as some experience as far as the RFID technology is concerned. From the other side, academics can exchange valuable information and experience with business consultants to make the RFID technology and other innovative technologies more effective and promising.

IDENTIFY KPIs FROM THE BUSINESS SYSTEM AND SUPPLY CHAIN MANAGEMENT IN RESPECT TO RFID TECHNOLOGY

Key performance indicators from the business system consist of all the basic operations and procedures from the suppliers to the end customers. Companies should focus on only a short list of KPIs which are critical for their operations management, customer service and financial viability [19].

Planning: it is an important KPI, as it includes sourcing, manufacture and delivery. Supply chain planning focuses on forecasting data, material sourcing, inventory management and all other activities in the supply chain. RFID will enable the supply chain network quickly and easily and also will comply with mandates and regulations.

Sourcing: this important KPI contributes to the demand for supply chain and it is more oriented on the customer. Market demand needs to be forecast from the supply chain. Supplier performance for delivery and all other procedures are of great importance.

Production: KPIs from the production part include operations, such as departure times, on time production, *just-in-time* production and order fill rate. Key metrics should focus on how quickly a product arrives at its final destination.

Delivery: customers need fast, reliable and best cost product delivery. On-time product delivery is complex as it can involve many distributors when it has to be delivered from one country to another.

While measuring the key performance indicators from the business system, RFID will come to give the business a competitive advantage by making customer needs visible, enhancing the visibility along the supply chain, defining accurate and timely asset tracking, making smart product recycling, improving productivity by generating the fastest and lowest cost method of acquiring the data, improving velocity, making reliable and accurate order forecasts, reducing inventory costs and human errors, increasing productivity, improving product quality and reliability, improving track transportation and warehousing channels and gaining favour with retailers to provide products with a better position.

FURTHER STUDY

After completing this article, the authors want to expand the research and present the results that arose from the answered questionnaires. These percentages will give a clear picture of how businesses are working and the extent to which businesses are cooperating with the universities in order to expand and bring new technologies.

CONCLUSIONS

Companies pay large sums in order to improve their supply chain performance [20]. It is worth it for companies to hire well educated personnel and managers and to identify the most important KPIs for every company's strategy and, therefore, gain a competitive advantage and a stronger position in the global market.

Picking and defining KPIs helps organisations to identify and correct potential problems and issues that they may face through the supply chain. All stakeholders in the supply chain should be involved in customer satisfaction and gaining a competitive advantage. KPIs are very important for every business and should be set up as they play a significant role in addressing future challenges. The challenge for Greece is to overcome the economic crisis and gain a strong position in the global market.

ACKNOWLEDGEMENT

This research has been co-financed by the European Union and Greek national funds through the Operational Programme *Education and Lifelong Learning* of the National Strategic Reference Framework (NSRF)-Research Funding Programme: Thales. Investing in Knowledge Society through the European Social Fund.

REFERENCES

1. Gunasekarana, A., Patelb, C. and McGaugheyc, R.E., A framework for supply chain performance measurement. *Inter. J. of Production Economics*, 87, 333-347 (2004).
2. Al-Turki, U. and Duffuaa, S., Performance measures for academic departments. *Inter. J. of Educational Manage.*, 17, 7, 330-338 (2003).
3. Pritchard, R.D., Roth, P.L., Jones, S.D. and Roth, P.G., Implementing feedback systems to enhance productivity: a practical guide. *National Productivity Review*, 10, 1, 57-67 (1990).
4. Neely, A., Adams, C. and Kennerly, M., *The Performance Prism: The Scorecard for Measuring and Managing Business Success*. London: Pearson Education Limited (2002).
5. Beamon, B.M., Measuring supply chain performance. *Inter. J. of Operations & Production Manage.*, 19, 3, 275-292 (1999).
6. Shepherd, C. and Günter, H., Measuring supply chain performance: current research and future directions. *Inter. J. of Productivity and Performance Manage.*, 55, 3/4, 242-258 (2006).
7. Peppas, V.P. and Moschuris, S.J., Three systems' collaboration for added value in the supply chain management area in Greece - the case of Greek market. *World Trans. on Engng. and Technol. Educ.*, 11, 3, 150-157 (2013).
8. Chao, C.C., Yang, J.M. and Jen, W.Y., Determining technology trends and forecasts of RFID by historical review and bibliometric analysis from 1991 to 2005. *Technovation*, 27, 5, 268-279 (2007).
9. Srivastava, B., Radio frequency ID technology the next revolution in SCM. *Business Horizons*, 4, 6, 60-68 (2004).
10. Asif, Z. and Mandviwalla, M., Integrating the supply chain with RFID: a technical and business analysis. *Communications of the Association for Infor. Systems*, 15, 24 (2005).
11. Sheffi, Y., RFID and the innovation cycle. *Inter. J. of Logistics Manage.*, 15, 1, 1-10 (2004).
12. Sayed, H.E., Supply chain key performance indicators analysis. *Inter. J. of Application or Innovation in Engng. & Manage.*, 2, 1, 201-210 (2013).
13. Pfeffer, J. and Salancik, G.R., *The External Control of Organizations: a Resource Dependence Perspective*. Stanford, Calif.: Stanford Business Books, USA (1978).
14. Hines, P., Lamming, R., Jones, D., Cousins, P. and Rich, N., *Strategic Performance Measurement Systems in Value Stream Management - Strategy and Excellence in the Supply Chain*. Harlow: Financial Times/Prentice Hall (2000).
15. Angappa, G., Kee-hung, L. and Chengb, E.T.C., Responsive supply chain: a competitive strategy in a networked economy. *The Inter. J. of Manage. Science*, 549-564 (2008).
16. Comm, C.L. and Mathaisel, D.F.X., Evaluating teaching effectiveness in America's business schools: implications for service marketers. *J. of Professional Services Marketing*, 16, 2, 163-170 (1998).
17. Lockett, J., *Effective Performance Management. A Strategic Guide to Getting the Best from People*. London: Kogan Page (1992).
18. Chen, S.H., Yang, C.C. and Shiau, J.Y., The application of balanced scorecard in the performance evaluation of higher education. *The TQM Magazine*, 18, 2, 190-205 (2006).
19. Chae, B., Developing key performance indicators for supply chain: an industry perspective. *Supply Chain Manage.*, 4, 6, 422-428 (2009).
20. Douglas, M.L., The eight essential supply chain management processes. *Supply Chain Manage. Review*, 18-26 (2004).