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Lean Six Sigma in the Service Industry

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1. Introduction

The business improvement methodology known as Lean Six Sigma is rooted in the manufacturing industry, where it developed over the past few decades, reaching widespread adoption worldwide. However, according to the *World Economic Outlook Database,* published in April 2011, by the International Monetary Fund (IMF, 2011), the distribution of PPP (Purchase Power Parity) GDP, in 2010, among various industry sectors in the main worldwide economies, reflected a decline in the industrial sector, with the service sector now representing three-quarters of the US economy and more than half of the European economies.

PPP GDP 2010	Agriculture	Industry	Service
European Union	5.7%	30.7%	63.6%
United States	1.2%	22.2%	76.7%
China	9.6%	46.8%	43.6%
India	16.1%	28.6%	55.3%

Table 1. PPP GDP Sector Comparison 2010.

In light of the increasing importance of the service sector, the objective of this chapter is to discuss whether the business improvement methodology known as Lean Six Sigma is applicable to the service industry as well, and illustrate some case study applications.

2. What is Lean Six Sigma?

Lean Six Sigma is a business improvement methodology that aims to maximize shareholders' value by improving quality, speed, customer satisfaction, and costs. It achieves this by merging tools and principles from both Lean and Six Sigma. It has been widely adopted widely in manufacturing and service industries, and its success in some famous organizations (e.g. GE and Motorola) has created a copycat phenomenon, with many organizations across the world willing to replicate the success.

Lean and Six Sigma have followed independent paths since the 1980s, when the terms were first hard-coded and defined. The first applications of Lean were recorded in the Michigan plants of Ford in 1913, and were then developed to perfection in Japan (within the Toyota Production System), while Six Sigma saw the light in the United States (within the Motorola Research Centre).

Lean is a process-improvement methodology, used to deliver products and services better, faster, and at a lower cost. Womack and Jones (1996) defined it as:

… a way to specify value, line up value-creating actions in the best sequence, conduct those activities without interruption whenever someone requests them, and perform them more and more effectively. In short, lean thinking is lean because it provides a way to do more and more with less and less—less human effort, less human equipment, less time, and less space—while coming closer and closer to providing customers with exactly what they want. (Womack and Jones, 1996:p.)

Six Sigma is a data-driven process improvement methodology used to achieve stable and predictable process results, reducing process variation and defects. Snee (1999) defined it as: 'a business strategy that seeks to identify and eliminate causes of errors or defects or failures in business processes by focusing on outputs that are critical to customers'.

While both Lean and Six Sigma have been used for many years, they were not integrated until the late 1990s and early 2000s (George, 2002; George, 2003). Today, Lean Six Sigma is recognized as: 'a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom line results' (Snee, 2010).

Lean Six Sigma uses tools from both toolboxes, in order to get the best from the two methodologies, increasing speed while also increasing accuracy.

The benefits of Lean Six Sigma in the industrial world (both in manufacturing and services) have been highlighted extensively in the literature and include the following:

1. Ensuring services/products conform to what the customer needs ('voice of the customer').
2. Removing non-value adding steps (waste) in critical business processes.
3. Reducing the cost of poor quality.
4. Reducing the incidence of defective products/transactions.
5. Shortening the cycle time.
6. Delivering the correct product/service at the right time in the right place. (Antony, 2005a; Antony, 2005b)

Examples of real benefits in various sectors are illustrated in Table 2.

One of the key aspects differentiating Lean Six Sigma from previous quality initiatives is the organization and structure of the quality implementation functions. In quality initiatives prior to Lean Six Sigma, the management of quality was relegated largely to the production floor and/or, in larger organizations, to some statisticians in the quality department. Instead, Lean Six Sigma introduces a formal organizational infrastructure for different quality implementation roles, borrowing terminology from the world of martial arts to define hierarchy and career paths (Snee, 2004; Antony, Kumar & Madu, 2005c; Antony, Kumar & Tiwarid, 2005d; Pande, Neuman & Cavanagh, 2000; Harry & Schroeder, 1999; Adams, Gupta & Wilson, 2003).

Service	Problem	Outcome	Benefits
Healthcare	Increase radiology throughput and decrease cost per radiology procedure in a hospital (Thomerson, 2001)	Significant improvement in radiology throughput and reduction in cost per radiology procedure	33 per cent increase in radiology throughput
	Poor patient safety due to high medication and laboratory errors (Buck, 2001)	Reduced medication and laboratory errors	22 per cent reduction in cost per radiology procedure $1.2 million in savings
	Overcrowded emergency department (Revere and Black, 2003)	Reduced time to transfer a patient from the ER to an inpatient hospital bed	Improved patient safety significantly $600,000/year in profit
Banking	Reduce customer complaints (Roberts, 2004)	Significant reduction in customer complaints and increase in customer satisfaction	10.4 per cent increase in customer satisfaction 24 per cent decrease in customer complaints
	Excessive internal and external call backs plus unacceptable credit processing time (Rucker, 2000)	Reduction in both internal and external call backs, reduction in credit processing time	Reduced internal call backs by 80 per cent
	High number of flaws in customer-facing processes (e.g. account opening, payment handling, etc.) (www.helpingmakingithappen.com)	Reduced flaws in all customer-facing processes	Increased customer satisfaction Improved process efficiency Reduced cycle time by over 30 per cent
	High returned renewal credit cards per month in a leading bank (Keim, 2001)	Significant reduction in the number of returned renewal credit cards	Defect rate reduced from 13,500 DPMO to 6,000 DPMO
	Excessive market losses on trading errors, high costs associated with electronic order corrections etc. in an investment banking unit (Stusnick, 2005)	Reduced trading errors significantly Reduced costs associated with order corrections, etc.	Several millions of dollars in savings Improved employee morale within the banking unit
Financial services	High administrative costs (www.executiveonline.co.uk)	Reduction in administration costs	Savings generated from this project are approximately $75,000/year
	Unacceptable wire transfer processing time to customers	Reduced wire transfer processing time by 40 per cent	Savings generated from the project are around $700,000/year
	Problems in accounts receivables within an accounting department (www.ssqi.com)	Improved cash flow	Annual savings are estimated to be well over $350,000
Utility services	Poor service delivery (www.executiveonline.co.uk)	Improved service delivery	Annual savings from the project is of the order of over $1.5 million
	High contract complaints resulted in customer dissatisfaction and high costs	Reduced the number of complaints after six sigma methodology was introduced	Complaints reduced from 109 to 55 on average per year
Miscellaneous	Poor delivery performance in a logistics company (Thawani, 2004)	Reduced the number of delayed deliveries	Sigma quality level of the process improved from 2.43 (176,000 DPMO) to 3.94 (7,400 DPMO) Improved customer satisfaction and increased market share, resulted in savings of $400,000 (approx.)
	Significant errors in a monthly publication for Wall Street investors and traders	Reduction in reporting and accounting errors	$1.2 million in estimated savings

Table 2. Benefits of Six Sigma in Service Organizations (Antony, Kumar & Cho, 2007).

3. Lean Six Sigma and the service industry

The service industry has its own special characteristics, which differentiate it from manufacturing and make it harder to apply Lean Six Sigma tools, which can be summarized in the following main areas (Kotler, 1997; Regan 1963; Zeithmal, Parasur and Berry 1985):

Intangibility: Although services can be consumed and perceived, they cannot be measured easily and objectively, like manufacturing products. An objective measurement is a critical aspect of Six Sigma, which requires data-driven decisions to eliminate defects and reduce variation. The lack of objective metrics is usually addressed in service organizations through the use of proxy metrics (e.g. customer survey).

Perishability: Services cannot be inventoried, but are instead delivered simultaneously in response to the demand for them. As a consequence, services processes contain far too much 'work-in-process' and work can spend more than 90% of its time waiting to be executed (George, 2003).

Inseparability: Delivery and consumption of service is simultaneous. This adds complexity to service processes, unknown to manufacturing. Having customers waiting in line or on the phone involves some emotional management, not present in a manufacturing process.

Variability: Each service is a unique event dependent on so many changing conditions, which cannot be reproduced exactly. As a result of this, the variability in service processes is much higher than in manufacturing processes, leading to very different customer experiences.

Owing to these inherent differences, it has been harder for service organizations, such as financial companies, health-care providers, retail and hospitality organizations, to apply Lean Six Sigma to their own reality. However, there are also great opportunities in the service organizations (George 2003):

- Empirical data has shown the cost of services are inflated by 30–80% of waste.
- Service functions have little or no history of using data to make decisions. It is often difficult to retrieve data and many key decision-makers may not be as 'numerically literate' as some of their manufacturing counterparts.
- Approximately 30–50% of the cost in a service organization is caused by costs related to slow speed, or carrying out work again to satisfy customer needs.

In the last few years, successful applications in service organizations have come to fruition and we will illustrate three possible applications: in a call centre, in human resources, and finally in a healthcare provider.

4. Case study 1: Lean Six Sigma in a call centre (Laureani et al, 2010a)

The two major types of call centres are outbound centres and inbound centres. The most common are inbound call centre operations. Almost everyone in their daily life has had to call one of those centres for a variety of reasons. Outbound centres are used more in areas such as marketing, sales and credit collection. In these instances, it is the call centre operators who establish contact with the user.

Although there are some differences between outbound and inbound call centres, they each have certain potential benefits and challenges, with regard to the implementation of Lean Six Sigma.

Benefits

Some of the benefits that Lean Six Sigma can deliver in a call centre are (Jacowski, 2008; Gettys, 2009):

1. Streamlining the operations of the call centre: Lean strategy helps in eliminating waste and other non-value added activities from the process.
2. Decreasing the number of lost calls: Six Sigma's root-cause analysis and hypothesis-testing techniques can assist in determining how much time to spend on different type of calls, thus providing a guide to the operators.
3. Better use of resources (both human resources and technology), thus leading to a reduction in the cost of running such centres.
4. Unveiling the 'hidden factory': establishing the root causes of why customers call in the first place can help in uncovering trouble further along the process, providing benefits that go further than the call centre itself, improving customer service and support.
5. Reducing employee turnover: call centres are usually characterized by high employee turnover, owing to the highly stressful work environment. A more streamlined operation would assist in reducing operators' stress, particularly in an inbound centre.

Challenges

Specific challenges of applying Lean Six Sigma in a call centre environment (Piercy & Rich, 2009):

1. The relentless pace of the activity (often 24/7) makes it more difficult for key staff to find the time to become involved in projects and Lean Six Sigma training.
2. The realization of an appropriate measurement system analysis (MSA) (Wheeler & Lyday, 1990) is difficult because of the inherent subjectivity and interpretation of some call types, failing reproducibility tests of different call centre operators.
3. High employee turnover, that normally characterizes call centres, makes it more difficult for the programme to remain in the organization.

Strengths	Weaknesses
• Root cause analysis can determine major reasons for customers' calls, helping to unveil problems further along the value stream map of the company	• Lean Six Sigma deployment requires significant investment in training, that may be difficult from a time perspective in a fast-paced environment such as a call centre
Opportunities	**Threats**
• Decrease number of lost calls • Reduce waiting time for calls in the queue • Improve employee productivity (i.e. number of calls dealt with by the hour)	• Lack of metrics • Lack of support from process owner • Preconceived ideas

Table 3. SWOT Analysis for the Use of Lean Six Sigma in a Call Centre.

Overall, the opportunities far outweigh the challenges. Call centres nowadays are more than just operations: they are the first, and sometimes a unique, point of contact that a company may have with its customers. Their efficient and effective running, and their timely resolution of customers' queries, all go a long way to establishing the company's brand and image.

Project selection is a critical component of success. Not all projects may be suitable candidates for the application of Lean Six Sigma, and this needs to be kept in mind in assessing the operation of a call centre. Also, different tools and techniques may be more suited to a specific project, depending on the nature and characteristics of the process it is trying to address.

Projects that better lend themselves to Lean Six Sigma share, *inter alia,* the following characteristics:

- The focus of the project is on a process that is either not in statistical control (*unstable*) or outside customer specifications (*incapable*). As already mentioned in the introduction, Six Sigma techniques focus on reducing the variation in a process, making them the ideal tools for tackling an incapable but stable process, whereas Lean tools focus more on the elimination of waste and would be the first port of call for streamlining an unstable process. Priority should be given to unstable processes, using Lean tools to eliminate the waste and simplify the process. Once it has stabilized, more advanced statistical tools from the Six Sigma toolbox, can be used to reduce variation and make the process capable.

- The root reason(s) for this has not been identified yet. It is important to start work on the project with an open mind and without any prejudice. Data and hard facts should guide the project along its path.
- Quantitative metrics of the process are available. A lack of measures and failing to realize a complete measurement system analysis (MSA) (Wheeler & Lyday, 1990) can seriously jeopardize any improvement effort.
- The process owner is supportive and willing to provide data and resources. This is critical for the ongoing success of the project; the process owner's role is discussed in detail in the Control Phase section.

Potential areas of focus for Six Sigma projects in call centres (Gettys, 2009):

- Lost call ratio out of total calls for an inbound call centre;
- Customer waiting/holding times for an inbound call centre;
- First-call resolution;
- Calls back inflating call volumes.

Call centres are increasingly important for many businesses and are struggling consistently with the pressure of delivering a better service at a lower cost. Lean Six Sigma can improve the operation of a call centre through an increase in first-call resolution (that reduces the failure created by failing to answer the query in the first place), a reduction in call centre operator turnover (leveraging on training and experience), and streamlining the underlying processes, eliminating unnecessary operations.

Given the large scale of many call-centre operations, even a relatively small improvement in the sigma value of the process can dramatically reduce the defect rate, increase customer satisfaction and deliver financial benefits to the bottom line (Rosenberg, 2005).

By focusing on eliminating waste, identifying the real value-adding activities and using the DMAIC tools for problem-solving, it is possible to achieve significant improvements in the cost and customer service provided (Swank, 2003).

5. Case study 2: Lean Six Sigma in HR administration (Laureani & Antony, 2010b)

In the late 1980s, when Motorola implemented Six Sigma originally, obtaining astonishing results, the company was then faced with the dilemma of how to reward its employees for these successes (Gupta, 2005). This was the first time Six Sigma and HR practices came into contact, and a more accurate definition of HR practices was needed.

If, in the past, the term HR was related only to administrative functions (e.g. payroll, timekeeping, etc.), the term has increased substantially, in the last few decades, to include the acquisition and application of skills and strategies to maximize the return on investment from an organization's human capital (Milmore et al, 2007).

HR management is the strategic approach to the management of all people that contribute to the achievement of the objectives of the business (Armstrong, 2006). As such it includes, but it is not limited to, personnel administration. In effect it includes all steps where an employee and an organization come into contact, with the potential of adding value to the organization (Ulrich, 1996).

As such, and merging terminology from Lean and HR, we define the following seven points as the Human Capital Value Stream Map:

1. Attraction
2. Selection
3. Orientation (or induction)
4. Reward
5. Development
6. Management
7. Separation

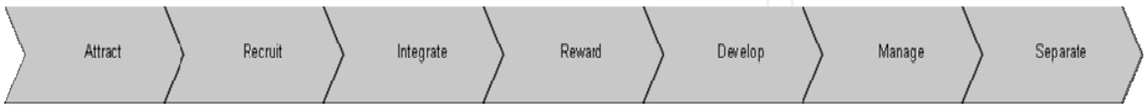


Fig. 1. Human Capital Value Stream Map.

The Human Capital Value Stream Map is a Lean technique that identifies the flow of information or material required in delivering a product or service to a customer (Womack & Jones, 1996). Human capital is the accumulated skills and experience of the human force in an organization (Becker, 1993).

The Human Capital Value Stream Map is the flow of human capital required for an organization to deliver its products or service to customers; the objectives of which are briefly described below:

- **Attract**: to establish a proper employer's brand that attracts the right calibre of individual.
- **Select**: to select the best possible candidate for the job.
- **Orient**: to ensure new employees are properly trained and integrated into the organization.
- **Reward**: to ensure compensation packages are appropriate and in line with the market.
- **Develop**: to distinguish talent and ensure career progression.
- **Manage**: to supervise and administer the day-to-day jobs.
- **Separation**: to track reasons for voluntary leavers and maintain a constructive relationship.

It is possible to apply Lean Six Sigma tools to each step of the Human Capital Value Stream Map, in order to eliminate waste in the HR process (Wyper & Harrison, 2000). For each step in the Human Capital Value Stream Map it is necessary to establish proper quantitative metrics that allow objective assessment and control of the process step (Sullivan, 2003). This makes use of the more quantitative statistical tools from the Six Sigma toolbox possible.

Establishing HR metrics can be controversial, with different parts of the organization having different objectives (Jamrog & Overholt, 2005), but the answer to these simple questions may help to focus on the real value each step can provide.

1. What is the expected deliverable of the step?
2. What are the relevant metrics and key performance indicators of the step?
3. What are the opportunities for defects in the step?

For recruitment, for example, the answers to the above questions may be as follows.

1. Hire, in the shortest possible time, new members of staff to fulfil a certain job.
2. The number of days to fill a vacancy (also define the acceptable norm for the organization).
3. Any job remaining vacant for longer than the acceptable norm.

Similar thought processes can be performed for other steps: having set metrics for each step of the Human Capital Value Stream Map, an organization is now in the position to apply Six Sigma DMAIC to it.

Six Sigma can be used to improve administrative processes, such as HR processes. Implementing the Six Sigma DMAIC breakthrough methodology in HR follows the same path as implementing it in any other part of the organization.

However, there are some specific key learning points and challenges for the HR area, such as:

- Difficulty in establishing an appropriate measurement system analysis and metrics;
- Data collection can be extremely difficult, as the project team is dealing with very sensitive issues; and
- Difficulty in performing any pilot or design of experiment. Any of these is going to impact on the behaviour of staff, making it difficult to measure its results accurately.

As a result, projects may last longer than the standard four to six months and the wider use of tools such as brainstorming and 'Kaizen' workshops with domain experts may be necessary (Lee et al, 2008).

Examples of potential Six Sigma projects in the HR function are:

- reduction of employees' turnover
- reduction in time and cost to hire a new employee
- reduction in training costs
- reduction in cost of managing employees' separation
- reduction in administrative defects (payroll, benefits, sick pay, etc.)
- reduction in queries from the employee population to the HR department.

Every area of an organization needs to perform better, faster and more cheaply, to keep the company ahead of the competition, and be able to satisfy ever-increasing customer expectations. HR is no exception: more cost-effective and streamlined HR processes will create value for the organization, instead of just being a support act for management (Gupta, 2005).

6. Case study 3: Lean Six Sigma in health-care delivery

Health care is a complex business, having to balance continuously the need for medical care and attention to financial data. It offers pocket of excellence, with outstanding advances in technology and treatment, together with inefficiencies and errors (Taner et al, 2007). Everywhere in the world, the financial pressures on health care have increased steadily in the last decade. While an ageing population and technological investments are often cited as culprits for these financial pressures, unnecessary operational inefficiency is another source

of cost increases, largely under the control of health-care professionals (de Koning et al, 2006).

Lean Six Sigma projects so far in the health-care literature have focused on direct care delivery, administrative support and financial administration (Antony et al, 2006), with projects executed in the following processes (Taner et al, 2007):

- increasing capacity in X-ray rooms
- reducing avoidable emergency admissions
- improving day case performance
- improving accuracy of clinical coding
- improving patient satisfaction in Accident and Emergency (A&E)
- reducing turn-around time in preparing medical reports
- reducing bottle necks in emergency departments
- reducing cycle time in various inpatient and outpatient diagnostic areas
- reducing number of medical errors and hence enhancing patient safety
- reducing patient falls
- reducing errors from high-risk medication
- reducing medication ordering and administration errors
- improving active management of personnel costs
- increasing productivity of health-care personnel
- increasing accuracy of laboratory results
- increasing accuracy of billing processes and thereby reducing the number of billing errors
- improving bed availability across various departments in hospitals
- reducing number of postoperative wound infections and related problems
- improving MRI exam scheduling
- reducing lost MRI films
- improving turn-around time for pharmacy orders
- improving nurse or pharmacy technician recruitment
- improving operating theatre throughput
- increasing surgical capacity
- reducing length of stay in A&E
- reducing A&E diversions
- improving revenue cycle
- reducing inventory levels
- improving patient registration accuracy
- improving employee retention

The focus has been on the improvement of clinical processes to identify and eliminate waste from the patient pathways, to enable staff to examine their own workplace, and to increase quality, safety and efficiency in processes (e.g. Fillingham, 2007; Silvester et al, 2004; Radnor and Boaden, 2008).

The barriers specific to the deployment of Lean Six Sigma in health care, in addition to the ones commonly present in other industries, are:

- Measurement: it is often difficult to identify processes, which can be measured in terms of defects (Lanham and Maxson-Cooper, 2003).

- Psychology of the workforce: in the health-care industry it is particularly important to not use jargonistic business language, as this has a high chance of being rejected or accepted with cynicism by medical professionals

The application of Lean Six Sigma in health care is still in its early stages. Therefore early successes in simple projects will pave the way for tackling more complicated initiatives in the future, initiating a positive circle of improvement, bringing clinical change on a broad scale.

Appropriately implemented, Lean Six Sigma can produce benefits in terms of better operational efficiency, cost-effectiveness and higher process quality (Taner et al, 2007), as the case studies presented in this paper illustrate.

The spiralling costs of health care means that unless health-care processes become more efficient, a decreasing proportion of citizens in industrialized societies will be able to afford high-quality health care (de Koning et al, 2006). Continuous process improvement is needed to ensure health-care processes are efficient, cost-effective and of high quality.

The five case study applications we have examined in this paper provide examples of how Lean Six Sigma can help to improve health-care processes. The adoption of similar programs in other hospitals across the health-care sector will help the delivery of high quality health care to an increasing population.

7. Conclusion

Lean Six Sigma is now accepted widely as a business strategy to improve business profitability and achieve service excellence, and its use in service organizations is growing quickly. However, there are a number of barriers to the implementation of Lean Six Sigma in services, such as the innate characteristics of services, as well as the manufacturing origins of Lean Six Sigma that have conditioned service managers to consider them as physical products only. On the other hand, as shown in the case studies, there are a number of advantages for the use of Lean Six Sigma in services (Eisenhower, 1999). Overall, the applications so far have showed the benefits (such as lowering operational costs, improving processes quality, increasing efficiency) to outweigh the costs associated with its implementation.

8. References

Adams, C., Gupta, P. & Wilson, C. (2003) *Six Sigma deployment*. Burlington, MA, Butterworth-Heinemann.

Antony, J. (2005a) Assessing the status of six sigma in the UK service organizations. *Proceedings of the Second National Conference on Six Sigma*, Wroclaw, pp. 1-12.

Antony, J. (2005b) Six Sigma for service processes. *Business Process Management Journal*, 12(2), 234-248.

Antony, J., Antony, F. & Taner, T. (2006), The secret of success. *Public Service Review: Trade and Industry*, 10, 12-14.

Antony, J., Kumar, M. & Cho, B.R. (2007) Six Sigma in services organizations: benefits, challenges and difficulties, common myths, empirical observations success factors. *International Journal of Quality Reliability Management,* 24(3), 294–311.

Antony, J., Kumar, M. & Madu, C.N. (2005) Six Sigma in small and medium sized UK manufacturing enterprises: some empirical observations. *International Journal of Quality & Reliability Management*, 22(8), 860-874.

Antony, J., Kumar, M. & Tiwari, M.K. (2005) An application of Six Sigma methodology to reduce the engine overheating problem in an automotive company. *IMechE – Part B*, 219(B8), 633-646.

Armstrong, M. (2006) *A handbook of human resource management practice.* London, Kogan Page.

Becker, G. S. (1993) *Human capital: a theoretical and empirical analysis, with special reference to education.* Chicago, University of Chicago Press.

de Koning, H., Verver, J. P. S., Van den Heuvel, J., Bisgaard, S. & Does, R. J. M. M. (2006) Lean Six Sigma in health care. *Journal for Healthcare Quality*, 28(2), 4-11.

Eisenhower, E. C. (1999) The implementation challenges of Six Sigma in service business, *International Journal of Applied Quality Management,* 2(1), 1-24

Fillingham, D. (2007) 'Can lean save lives? *Leadership in Health Services,* 20(4), 231-41.

George, M.L. (2003) *Lean Six Sigma for service: how to use Lean speed and Six Sigma quality to improve services and transactions*. New York, McGraw-Hill.

George, M.L. (2002) *Lean Six Sigma: combining Six Sigma quality with Lean speed.* New York, McGraw-Hill.

Gettys, R. (2009) *Using Lean Six Sigma to improve Call Centre operations*. [Online]Available from: http://finance.isixsigma.com/library/content/c070418a.asp [Accessed 22nd January 2009].

Gupta, P. (2005) Six Sigma in HR, *Quality Digest*, QCI International.

Harry, M. and Schroeder, R. (1999) *Six Sigma: The breakthrough management strategy*

International Monetary Fund (IMF), (2011) *World Economic Outlook Database.* [Online] Available from: http://www.imf.org/external/pubs/ft/weo/2011/01/weodata/index.aspx. [Accessed 7th August 2011]

Jacowski, T. (2008) *Maximizing call centre resource utilization with Six Sigma*. [Online] Available from: http://ezinearticles.com/?Maximizing-Call-Centre-Resource-Utilization-With-Six-Sigma&id=1014905. [Accessed 22nd January 2009].

Jamrog, J. J. & Overholt, M. H. (2005) The future of HR metrics, *Strategic HR Review, 5* (1) 3-3.

Kotler, P. (1997) *Analysis, planning ,implementation and control*, 9th ed. Prentice-Hall.

Lanham, B. & Maxson-Cooper, P. (2003) Is Six Sigma the answer for nursing to reduce medical errors?, *Nursing Economics*, 21(1), 39-41.

Laureani, A. & Antony, J. (2010) Reducing employees' turnover in transactional services: a Lean Six Sigma case study, *International Journal of Productivity and Performance Management,* 59(7), 688-700

Laureani, A., Antony, J. & Douglas, A. (2010) Lean Six Sigma in a call centre: a case study, *International Journal of Productivity and Performance Management,* 59(8), 757-768

Lee, Y., Chen, L. & Chen, S. (2008) Application of Six Sigma methodology in human resources to reduce employee turnover rate: a case company of the TFT-LCD industry in Taiwan. *International Journal of Operations and Quantitative Management, 14* (2), 117-128.

Milmore, M. et al, (2007) *Strategic human resource management: contemporary issues.* Prentice Hall/Financial Times.

Pande, P., Neuman, R. & Cavanagh, R. (2000) *The Six Sigma way: how GE, Motorola and other top companies are honing their performance*. New York, McGraw-Hill.

Piercy, N. & Rich, N. (2009) Lean transformation in the pure service environment: the case of the call centre. *International Journal of Operations & Production Management,* 29 (1), 54-76.

Radnor, Z. & Boaden, R. (2008) Editorial: does Lean enhance public services?, *Public Money and Management,* 28(1), 3-6.

Regan, W.J. (1963) The Service Revolution, *Journal of Marketing*, 47, 57-62

Rosenberg, A. (2005) Six Sigma: the myth, the mystery, the magic: can Six Sigma really make an impact in your call centre? [Online] Available from http://www.callcentremagazine.com/shared/article/showArticle.jhtml?articleId=59301130 [Accessed 22nd January 2009].

Silvester, K., Lendon, R., Bevan, H., Steyn, R. & Walley, P. (2004) Reducing waiting times in the NHS: is lack of capacity the problem? *Clinician in Management,* 12(3), 105-11.

Snee, R. D. (2010) Lean Six Sigma: getting better all the time, *International Journal of Lean Six Sigma,* 1(1), 9–29.

Snee, R.D. (2004) Six Sigma: the evolution of 100 years of business improvement methodology. *International Journal of Six Sigma and Competitive Advantage*, 1(1), 4–20.

Snee, R. D. (1999) Why should statisticians pay attention to Six Sigma? *Quality Progress,* 32(9), 100–103.

Sullivan, J. (2003) *HR metrics the world class way,* Kennedy Information.

Swank, C. (2003) The Lean service machine. *Harvard Business Review,* October, 123-129.

Taner, M. T., Sezen, B. & Antony, J. (2007) An overview of Six Sigma applications in the health-care industry. *International Journal of Health Care Quality Assurance,* 20(4), 329-340

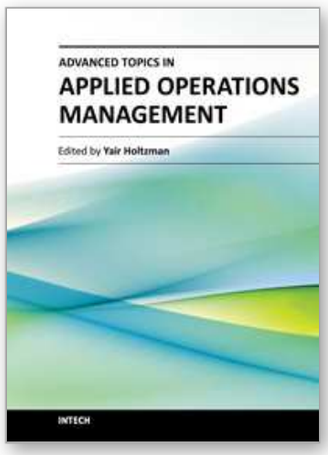
Ulrich, D. (1996) *Human resource champions. The next agenda for adding value and delivering results.* Boston, Harvard Business School Press.

Wheeler, D. J. & Lyday, R. W. (1990) *Evaluating the measurement process.* 2nd ed. SPC Press.

Womack, J. P. & Jones, D. T. (1996) *Lean thinking*. New York, Simon & Schuster.

Wyper, B. & Harrison, A. (2000) Deployment of Six Sigma methodology in human resource function: a case study. *Total Quality Management,* 11, (4/5/6), 720-727.

Zeithaml, V.A., Parasuraman, A. & Berry, L.L. (1985), Problems and strategies in services marketing, *Journal of Marketing*, 49 (Spring), 33-46.



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The chapters in Advanced Topics in Applied Operations Management creatively demonstrate a valuable connection among operations strategy, operations management, operations research, and various departments, systems, and practices throughout an organization. The authors show how mathematical tools and process improvements can be applied effectively in unique measures to other functions. The book provides examples that illustrate the challenges confronting firms competing in today's demanding environment bridging the gap between theory and practice by analyzing real situations.

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