

THIRD EDITION  
**OPERATIONS  
MANAGEMENT**  
THEORY AND PRACTICE

**B. MAHADEVAN**

Introducing  
MyLab | South Asia  
Operations  
Management  
See inside cover  
for details

Supplier  
Procurement  
Manufacture  
Supply Chain  
Product Inventory  
Distribution  
Logistics  
Retail  
Customer



third edition

# Operations Management

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THEORY AND PRACTICE

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third edition

# Operations Management

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THEORY AND PRACTICE

**B. Mahadevan**

*Indian Institute of Management Bangalore*

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*To*

*my parents, Balu and Saroja,*

*my wife Sujatha and*

*my daughter Dhrithi*

## ABOUT THE AUTHOR

B. Mahadevan is a professor of operations management at the Indian Institute of Management Bangalore, where he has been teaching since 1992. He was also the Dean (Administration) of the institute and a member of the Governing Board of IIM Bangalore for four years. He has more than 23 years of wide-ranging experience in teaching, research, consulting and academic administration at IIM Bangalore and other reputed institutions such as IIT Delhi and XLRI, Jamshedpur. Earlier, he was the Chief Editor of *IIMB Management Review*, the premier Indian journal for management educators, consultants and practitioners. He was also the EADS–SMI Chair Professor for sourcing and supply management at IIM Bangalore.

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Apart from *Operations Management: Theory and Practice*, Professor Mahadevan is also the author of *The New Manufacturing Architecture* and has developed software that addresses issues in restructuring manufacturing systems for competitive advantage. His research interests include supply chain management issues in e-markets and e-auction.

Professor Mahadevan's other interests include researching the possibility of using ancient Indian wisdom to address contemporary concerns. He is active in inculcating these ideas among his students and the youth through various forums and public lectures. He was also a member of the Central Sanskrit Board, an advisory body to the Ministry of HRD, Department of Education on all Sanskrit policy issues in the country.



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# PREFACE

## OBJECTIVES

*Operations Management: Theory and Practice* is the successful culmination of evolved ideas and clarity of thought arising out of teaching the subject at the Indian Institute of Management Bangalore for nearly 22 years. This book is the outcome of continuous testing of alternative ideas, concepts and pedagogical designs with MBA students, working executives from diverse industries, and research scholars.

Although there are several books available on the subject written by international authors, students find it difficult to relate to the examples used in them. The basic concept of this book is to bridge this critical gap by preserving all the salient features one usually finds in international textbooks, and at the same time, to enrich the book with contextually relevant examples. Throughout my teaching career, I have discovered that contextual references can go a long way in helping the students relate to the concepts discussed. Furthermore, such references can fuel their imagination and improve their understanding of concepts. Therefore, the examples and the Ideas at Work boxes in this book draw the students' attention to the issues faced by Indian organizations while applying the concepts discussed in the book. They also provide insights on the variations adopted by such firms in the practical application of these concepts. Since several firms and their product–service offerings are referenced throughout this book, I have provided an index of companies at the end of the book.

Throughout the book, I have made an effort to provide a pleasant experience of going through seemingly tough models and concepts in operations management. I hope the readers will enjoy reading the book, and I look forward to receiving comments and suggestions from the students and teachers using this book at [bmahadevan207@gmail.com](mailto:bmahadevan207@gmail.com).

## NEW TO THE THIRD EDITION

I am thankful to the instructors and students for providing several useful suggestions for potential improvements in the second edition. These have largely influenced the work on this edition. While retaining the most appreciated features of the earlier editions—Ideas at Work boxes, solved quantitative examples, and illustrations and examples from the Indian context—I have updated the third edition to include a more current and holistic coverage of operations management.

Here are the highlights of the changes in the third edition:

- **Chapter reorganization:** The chapters have been reorganized so that students can easily position the relevance of the topics discussed and understand the critical linkages between various topics discussed in other chapters in a better way.
- **Changes in chapter titles:** While incorporating the updates and changes in the chapter content, I have taken a more balanced perspective of topics by including more service sector applications and examples. This has necessitated, for example, to change the title of Chapter 15 to “Operations Planning”.
- **New chapter:** Sustainability is increasingly becoming important for businesses. Several of the current students will be required to play a key role in managing businesses that are also



sustainable in their operations. In order to equip the students with the necessary understanding of the related issues, a new chapter—Chapter 3 titled “Sustainability in Operations”—has been introduced in this edition.

- **Updated material:** Several topics such as the design of manufacturing processes, lean management and six sigma have been revised to make them more comprehensive. Moreover, many of the Ideas at Work boxes and the data provided in the tables have been updated to reflect recent events. The description of the new attempts by businesses to address sustainability and project management pertaining to Terminal 3 of Indra Gandhi International Airport, New Delhi, are some examples in this category.
- **Additions to the end-of-chapter exercises: Mini Projects and Net-wise Exercises** have been updated in this edition to provide a wide range of application-oriented problems to students. Moreover, additional problem sets have been included in several chapters. These additions bring the students closer to the real-life applications of various concepts and help them relate to these concepts better.
- **Video Insights:** This is a new feature introduced in this edition. In an era of media convergence and availability of useful information on the Internet, the students need to benefit from these and expand their understanding and scope of application of the concepts discussed in the book. To facilitate this process, over 15 videos have been identified and their URLs have been provided so that students can pursue them. These videos cover the actual working of a variety of manufacturing and service firms and expert opinions and interviews on certain aspects of operations.
- **Formula Review:** In chapters where several formulae have been introduced, a new feature has been added at the end of such chapters. This provides a quick summary of all important formulae covered in that chapter.

## ORGANIZATION

*Operations Management: Theory and Practice (3e)* comprises 19 chapters, which have been divided into four sections.

**Part I:** *Conceptualizing Sustainable Operations* consists of four chapters that introduce how to understand the operations function, the role of strategy in creating successful operations in firms, the need for making it sustainable and the manner by which such firms eventually become a physical reality to conduct their operations in the real life.

**Part II:** *Operations and the Value Chain* deals with the important issue of supply chain management in three chapters. The topics covered in these chapters include supply chain management, facilities, location and sourcing and supply management.

**Part III:** *Designing Operations* consists of six chapters that deal with various elements of the design of an operations system. This includes process and capacity analysis, design of manufacturing processes, design of service systems, product development and total quality management.

**Part IV:** *Planning and Control of Operations* consists of six chapters in which alternative approaches for the planning and control of operations are discussed.

## PEDAGOGICAL FEATURES

To enable students to understand the concepts discussed in the chapters, the following pedagogical features have been incorporated into each chapter:

**VIDEO INSIGHTS 2.1**

A good operations strategy invariably takes an organization towards operational excellence. To find the path of operational excellence, find the video resources or Student Resources under section **Downloadable Resources** in the sub-sections **Bonus Material**.

**Video Insights**

These are provided in each chapter to help students understand the concepts better. Document containing the URLs can be downloaded from the resource website.

**ideas at Work 2.1**

**Café Coffee Day: A Strategy for Affordable Luxury**

Café Coffee Day (CCD) is India's favourite coffee shop for the young and the young at heart. It is a part of India's largest coffee conglomerate, Amalgamated Bean Coffee Trading Company Limited. CCD has 20 seconds machine coffee priced at ₹15,000 per cup.

**Ideas at Work boxes**

This novel feature in each chapter directly relates chapter concepts to real-world practices in the Indian scenario and enables students to develop an application-oriented approach.

**PROBLEMS**

- |  |  |
|--|--|
| <p>1. Quick Photo Solutions is in the business of processing photographic films. The annual fixed cost of equipment incurred by Quick Photo Solutions is ₹600,000. The demand for film processing is 50 rolls per day, and they work for 250 days a year. The variable cost of processing a film (including labour, power, and chemicals) is ₹90 per roll.</p> | <p>2. Raja runs a printing press. His physical layout is such that the cost of printing a page is ₹100. The cost of paper is ₹10 per page.</p> |
|--|--|

**Problems**

The quantitative problems at the end of each chapter enable students to deepen their understanding of the concepts and models of Operations Management.

**MINI PROJECTS**

- |   |  |
|---|--|
| <p>1. Select two close competitors in any sector of industry and study their annual reports for the last three years.</p> <p>(a) Compute relevant measures of supply chain performance for both of them for these three years and report your significant observations from the study.</p> <p>(b) Do you see any significant change in the performance in these companies during this period?</p> | <p>tools, fast project network.</p> <p>(a) Compare the performance of a company with its competitors.</p> <p>(b) What are the key factors that affect the performance of a company?</p> <p>(c) Report your findings.</p> |
|---|--|

**Mini Projects**

To help instructors guide students through an applied learning process, the chapters provide Mini Projects. These ideas enable students to broaden their understanding of the subject through extended work.



**NET-WISE EXERCISES**

1. Visit the following links:

- Spice Jet: <http://www.spicejet.com>
- Jet Airways: <http://www.jetairways.com/IN/>

On these Web sites, there are several links you can click on. Click on **Products and Services**, **Plan Your Travel**, and **About Us**. After visiting both the sites, write a report to address the following questions:

(a) How do the two airlines differ in their objectives and

After visi  
answer th  
(a) How  
differ  
(b) Whic  
(c) Why  
oper:  
3. Downloa

**Net-wise Exercises**

Through Net-wise Exercises, students are exposed to online data so that they can access a wealth of information on various additional topics related to the chapter and also apply the chapter concepts to this data.

**CASE: GINGER HOTEL**

Roots Corporation Limited is a fully owned subsidiary of the Indian Hotels Company Limited (IHCL), which is a part of the Tata Group. With more than 90 properties, IHCL is India's largest hotel chain. It has been in the hospitality sector for

over a centur  
of hotels und  
was launchec  
Ginger hotels

**Cases**

End-of-chapter case studies provide insights into the operations management practices of organizations in the service sector as well as the manufacturing sector.

**SUPPLEMENT 10A: SIMULAT**

**Simulation as a Modelling Tool**

Consider a branch of the State Bank of India in a centrally located place such as the Nariman point in Mumbai. Let us

War period.  
complex real  
problem.

**Supplements**

End-of-chapter supplements help students understand complex topics such as simulation and linear programming.

## TEACHING AND LEARNING PACKAGE

A variety of resources has been provided with this book to help students understand the concepts better and to aid instructors in teaching the subject. These include:

- ▶ **Videos Insights:** 15 video URLs have been identified and provided for the students to connect theories taught in the classroom with real-life examples. This pedagogical feature brings together videos giving insight into prevalent industrial practices, manufacturing procedures and interviews for conceptual clarity.
- ▶ **Instructors' Manual:** Instructors have access to special material prepared for them, including an instructors' manual with suggested cases for use, alternative course outlines and other relevant information.



- › **MS Excel-based Solutions:** All the exercises in the book are available in the form of Excel files. The files have additional scope for “what if” scenarios in some problems, enabling instructors to create as many variations of the problem as required.
- › **PowerPoint Slides:** All chapters have a corresponding PowerPoint file highlighting the key concepts discussed in that chapter.
- › **Multiple-choice questions:** The multiple-choice questions on the companion Website are designed to test students’ comprehension of key topics.

Both Instructor and student resources are available on the book’s companion Website, [www.pearsoned.co.in/bmahadevan](http://www.pearsoned.co.in/bmahadevan)

## ACKNOWLEDGEMENTS

The role played by students, executives, research scholars and my colleagues at IIM Bangalore in shaping my thinking is invaluable and beyond verbal quantification. Over the years, they have constantly challenged my thinking and provided me with new perspectives on the subject. Many industry participants and MBA students at IIM Bangalore have worked with me on several live operations management problems during the past ten years. These problems invariably culminated in some written project reports. I have drawn many examples from these reports while discussing several concepts in the book. I am thankful to all of them for their contributions.

I am thankful to several Indian companies that have permitted me to use some of their material in the book.

I greatly appreciate the assistance provided by Neeraj Bhalla, Associate Editor—Acquisitions (B&E), Purushothaman, Production Editor— Higher Education, and his team at Pearson Education for their professional approach and meticulousness that have significantly contributed to improve the quality of this edition, and I am thankful to these people for their dedication and support in this project.

As always, my wife Sujatha and my daughter Dhrithi provided me with moral support throughout the development of this project.

**B. Mahadevan**



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# Operations Management: Trends and Issues



## CRITICAL QUESTIONS


*After going through this chapter, you will be able to answer the following questions:*

- What do you understand by the term operations management?
- What is the status of the manufacturing and service industries in India?
- What are the emerging opportunities and challenges for operations management?
- Can the principles of operations management be applied to both manufacturing and service organizations?
- What is the role of operations in an organization?
- What are the key components of an operations management system? What is the nature of the interaction among them?



The success of Narayana Health (NH) is mainly due to the proper implementation of operations management in its day-to-day activities. The growth of NH to 14 multi-speciality hospitals is mainly because of its planning, passion, and compassion; this is what operations management is all about. Managing a workforce of 12,000 is mainly attributed mainly to strategic thinking and implementation. The success rate is made possible by employing cost reduction in several methods. The main vision of the NH group is not to lose a single patient in terms of want of money and conducting the surgeries in a cost-effective manner.

**Source:** Franck Boston. Shutterstock

  
**ideas**  
at Work  
1.1

## Narayana Health (NH): A Journey That Began with Wining the Heart of India

Indians are three times prone to heart diseases than Europeans. By 2013, while there is a need for 2.5 million heart surgeries per year in India, we are doing only 90,000. Moreover, India produces 80 cardiologists a year compared to 800 in the US. There is a huge shortage of doctors and paramedical staff in the country. To complicate the matter even more, 70% doctors are in urban areas, whereas 70% people live in rural areas. This appears to be a serious problem of lack of adequate healthcare for the citizens. However, a closer look at the story of Narayana Health (NH) suggests that mass healthcare cover is not about money but about planning, passion, and compassion. Operations Management can work at its best to address such problems.

NH journey first started with a 300-bed hospital started by Dr. Devi Shetty in the outskirts of Bangalore city in 2001 that began providing heart surgeries to patients at significantly low costs. Currently, the group has 14 hospitals in multiple locations with multiple specialties that offer a total of 5,700 beds. Over the next 18 months, there are plans to add new hospitals in Siliguri, Bhubaneswar, Mysore, Mumbai, and Delhi in addition to Cayman Islands and Malaysia, which will add another 2,500 beds capacity to the NH network. There are plans to expand this to about 30,000 beds by 2020. On account of this, the work force is likely to grow from the current strength of 12,000 to nearly 40,000. Managing such a massive expansion requires sound strategic thinking, creation of new facilities in a cost-effective manner, and operating them on a day-to-day basis with better planning. All these issues belong to the domain of Operations Management.

Many of the operational aspects of the NH network are governed by the vision that nobody should go back from the hospital for want of money. A heart surgery package at NH could be anywhere between ₹75,000 and ₹150,000 compared to a typical cost of ₹300,000 in other hospitals. Achieving such dramatic cost reduction calls for employing several methods. These include input cost reduction, benefiting

from process innovations and scale economies, and bringing innovative ideas in design of facilities and resource deployment. Further, productivity improvements would be very crucial and an ongoing activity in such a system. In NH, we find several examples illustrating these.

Due to volumes and supplier development efforts, NH is able to buy a pair of glove at ₹4.50 as against ₹9.50 by directly sourcing it from Malaysia. Many of the expensive equipment such as MRI scan machine are installed by vendors on a pay-per-use model rather than an outright purchase. This brings down the cost of an MRI scan and also increases its utilization. Hospitals are located on the outskirts of the cities to bring down the capital costs. The Mysore cardiac hospital was built using pre-fabricated materials and has no air-conditioning, except in operation theatres, thereby bringing down the cost of the facility dramatically low.

Another strategy to bring down the cost is to increase the volume of patient flow. To achieve this, NH has diversified into multi-specialties (such as Eye care, Orthopaedics, Neuroscience, and so on). Furthermore, NH recruits the best doctors and pays them as per the best industry standards. However, they are convinced to work a little extra. For the doctors at NH, 10 years ago, the plan was to do five surgeries a day with a 150-bed capacity, which itself was felt high. However, currently with 5,700 beds, they perform 30 surgeries a day. As a result, nearly 10–12% of all cardiac surgeries performed in India is done in NH network.

Narayana Health is an example of a service system. Like NH, every other service organizations as well as manufacturing organizations face similar set of issues, although in varying degrees. As illustrated in the case of NH, these issues can be addressed by applying several tools and techniques, collectively known as Operations Management.

**Source:** Based on Babu, V. (2012), "Pulse on the future", *Business World*, March 5, 2012, pp 40–45; Chaki, D. (2013), "Straight from the heart", *Business India*, Sep. 30–Oct. 13, 2013, pp 61–63.



## 1.1 INTRODUCTION TO OPERATIONS MANAGEMENT

Manufacturing, service, and agriculture are the major economic activities in any country. In India, manufacturing and services together constitute nearly 75 per cent of the gross domestic product (GDP). In recent years, growth in the GDP has been primarily due to the growth in these sectors of the economy. Moreover, the share of the service sector in the GDP has grown steadily from about 40 per cent to over 51 per cent between 1996 and 2006. In view of their contribution to the country's GDP, management of manufacturing and service operations are important economic activities. Significant improvements in productivity and cost savings can be achieved through operations management—a discipline that focuses on activities that relate to the planning and control of operations in manufacturing and service organizations. Efficient operations management can also have a positive impact on the overall health of the economy.

A manufacturing firm essentially engages in converting a variety of inputs into products that are useful for individuals and organizations. For example, a manufacturer of machine tools employs several production workers, buys raw material and components from various suppliers, and manufactures machine tools in a factory using an extensive array of manufacturing facilities. In this case, the factory encompasses a large number of interrelated conversion processes for the transformation of raw material into the final product, that is, the machine tool.

A service organization, on the other hand, responds to the requirements of customers and satisfies their needs through a service delivery process. Service organizations leave an impression in the minds of their customers through their service delivery. Typical examples of such organizations include management consultancies, automobile garages, hotels, hospitals and banks. A service organization may not always make use of material inputs and may not always produce products that are used by the customer. For instance, a law firm providing legal consultancy to its clients may not provide material inputs to the system or produce material output. Instead, the input and output are informational and experiential in nature. However, in the case of a service system like an automobile garage, a restaurant or a health care system, there are material inputs and material outputs (in the form of products consumed by the customers, as in the case of a restaurant). Despite this difference, service systems also have a conversion process that utilizes resources and delivers useful outputs from the system.

An *operations system* is defined as one in which several activities are performed to transform a set of inputs into a useful output using a transformation process. These inputs and outputs can be tangible, in the form of raw materials and physical products, or intangible, in the form of information and experiences. Viewed in this manner, manufacturing and service systems could be broadly classified as operations systems. **Operations management** is a systematic approach to addressing issues in the transformation process that converts inputs into useful, revenue-generating outputs. Four aspects of this definition merit closer attention:

- 1) *Operations management is a systematic approach.* It involves understanding the nature of issues and problems to be studied; establishing measures of performance; collecting relevant data; using scientific tools, techniques, and solution methodologies for analysis; and developing effective as well as efficient solutions to the problem at hand. Therefore, for successful operations management, the focus should be on developing a set of tools and techniques to analyse the problems faced within an operations system.
- 2) *Operations management involves addressing various issues that an organization faces.* These issues vary markedly in terms of the time frame, the nature of the problem, and the commitment of the required resources. Simple problems include deciding how to re-route jobs when a machine breaks down on a shop floor, or how to handle a surge in demand in a service system. On the other hand, decisions such as where to locate the plant, what capacity to build in the system, and what types of products and services to offer to the customers require greater commitment of resources and time.

Operations management provides alternative methodologies to address such wide-ranging issues in an organization.

**Operations management** is a systematic approach to addressing issues in the transformation process that converts inputs into useful, revenue-generating outputs.

- 3) *Transformation processes are central to operations systems.* The transformation process ensures that inputs are converted into useful outputs. Therefore, the focus of operations management is to address the design, planning, and operational control of the transformation process.
- 4) *The goal of operations management is to ensure that the organization is able to keep costs to a minimum and obtain revenue in excess of costs through careful planning and control of operations.* An appropriate performance evaluation system is required for this. Therefore, operations management also involves the development of performance evaluation systems and methods through which the operating system can make improvements to meet targeted performance measures.

Since manufacturing and service organizations form the operations system, it helps to understand the prevalent trends and the status of manufacturing and service organizations in India before we dwell on the various elements of operations management.

## 1.2 MANUFACTURING AND SERVICE SECTOR TRENDS IN INDIA

The index of industrial production (IIP) is a measure of the growth in the manufacturing sector. The Centre for Monitoring Indian Economy (CMIE) collects data on several macroeconomic indicators, including the IIP. Table 1.1 shows some of the salient aspects of the manufacturing and service sectors of the Indian economy. It is evident from Table 1.1 that the corporate sector has been going through tough times. There has not been much growth in sales revenue. However, there has been a steady increase in operating expenses and compensation to the employees. This has resulted in a situation where the profit after tax (PAT) has been progressively and significantly shrinking in the last three years. The service sector companies have been experiencing this more significantly than the manufacturing sector companies as evident from the table. On the whole, this points to the importance of deploying sound operations management practices in both manufacturing and service sectors of the Indian economy.

Over the years, there has been an increase in raw-material consumption. This perhaps indicates that manufacturing organizations are increasingly buying components and semi-processed items from suppliers. Furthermore, there has been a gradual increase in the cost of material and labour, which are primary inputs in the manufacturing system. Such an increase in the input cost is likely to put greater pressure on firms to cut down waste and improve productivity to remain

**TABLE 1.1** Salient Aspects of the Corporate Sector of the Indian Economy

Index of Industrial Production	2009-10	2010-11	2011-12	2012-13
Manufacturing	4.84	8.95	3.00	1.29
Capital goods	0.99	14.75	-3.97	-6.04
Consumer goods	7.65	8.57	4.37	2.43
Intermediate goods	6.03	7.39	-0.62	1.60
<b>Corporate sector performance</b>				
<b>Manufacturing sector</b>				
Sales	5.0	20.7	19.3	9.3
Operating expenses	4.8	22.3	19.6	10.1
Raw materials expenses	6.9	25.1	21.5	8.3
Compensation to employees	10.9	15.0	9.1	12.7
Profit After Tax (PAT)	43.1	15.4	18.4	-4.6
No. of companies	8751	8320	5690	3978
<b>Non-financial services sector</b>				
Sales	8.3	15.7	13.6	2.7
Operating expenses	6.1	17.7	15.3	1.3
Compensation to employees	5.3	15.0	14.3	14.1
Profit After Tax (PAT)	15.3	-28.0	-54.5	-7.7
No. of companies	6137	6125	4328	3065

All numbers in the table represent growth % over the previous year.

Data compiled from Economic Outlook of Centre for Monitoring Indian Economy (CMIE) using their time series data available at <http://economicoutlook.cmie.com>



competitive in the market. Therefore, the focus areas of operations management are likely to be in the areas of better supplier management, elimination of waste from the system, and improvement in overall productivity. Several sectors of the industry have been focusing on some of these initiatives.

Globally, India is emerging as an important manufacturing base and is competing closely with China in attracting several multinational companies to set up their manufacturing plants. Several studies point to emerging opportunities for Indian manufacturing to grow and attain a global presence. India has a unique advantage in the form of abundant low-cost labour and technical manpower. The Global Manufacturing Competitiveness Index 2013 released by Deloitte rated India at number four, next to China, Germany, and the US among 38 countries. It predicted India to reach the second position in the next 5 years. The report suggested that India's rich talent pool of scientists, researchers, and engineers as well as its large, well-educated English-speaking workforce and democratic regime would make it an attractive destination for manufacturers. Global manufacturing executives increasingly view India as a place where they can design, develop, and manufacture innovative products for sale in local as well as in global markets. Therefore, Indian manufacturing firms can, on the one hand, exploit the low-cost advantage as an entry strategy to capture global markets and, on the other develop, unique capabilities to position as an active participant in the global value chain.

The examples discussed here underscore the need for use of operations management to remain competitive in business and tap the emerging opportunities in the global arena. Effective operations management also requires a greater understanding of the various activities pursued under its banner and the critical linkages between operations and other aspects of business.

### 1.3 SERVICES AS A PART OF OPERATIONS MANAGEMENT

The service sector encompasses a wide spectrum of activities in every country. The growth of the service sector in India during 2002 to 2007 has been very significant. Table 1.2 provides some details on the share of some sectors of services in the overall GDP. The central government began taxing three services in 1994–95. This has grown steadily, and as of 2012–13, the number of services taxed has gone up to 119. During this period, both the number of assesseees and the service tax revenue has been growing very rapidly. According to the Central Board of Excise and Customs (CBEC), between 1994–95 and 2012–13 the tax revenue has grown from ₹4.1 billion to ₹1.325 trillion.<sup>1</sup> These figures indicate the growing importance of services in the Indian economy and the need to apply management practices to plan and control operations in the service sector.

Although services and manufacturing are classified as separate sectors in a macroeconomic sense, from the perspective of operations management, this separation is artificial. In operations management, a “pure product” and a “pure service” are just two ends of the spectrum, and not separate entities. In reality, a vast majority of operations share a continuum of services and products. Therefore, most of the principles, tools and techniques of operations management apply to both these sectors. This product–service continuum is illustrated in Figure 1.1.

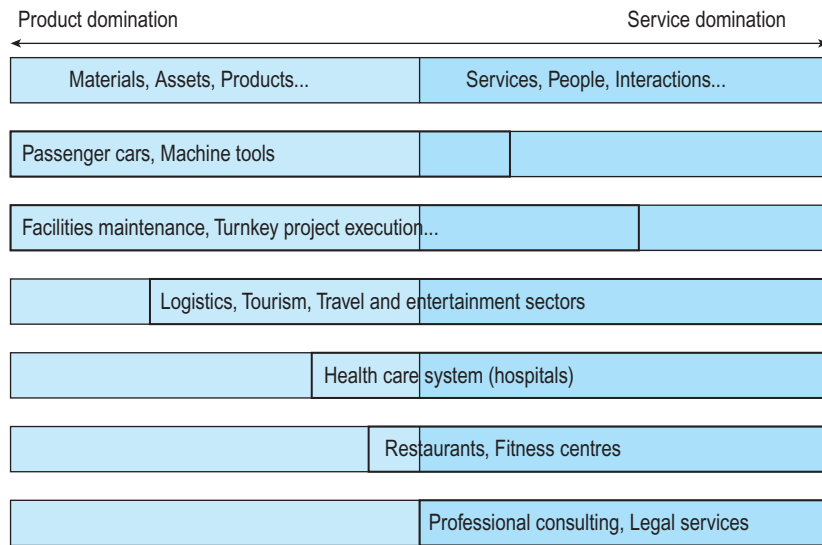
**TABLE 1.2** Service Sectors in India: Share of GDP in Percentage

	2008–09	2009–10	2010–11	2011–12	2012–13#
<b>Service sector growth rates in GDP</b>					
Trade, hotels, transport, and communications	16.9	16.5	17.2	18.0	25.1
Transport, storage, and communications	7.8	7.7	7.3	7.1	
Financial services, insurance, real estate, and business services	15.9	15.8	16.0	16.6	17.2
Community, social, and personal Services	13.3	14.5	14.0	14.0	14.3
Construction	8.5	8.2	8.2	8.2	8.2
Total (including construction)	62.4	62.7	62.6	63.9	64.8

# Advanced Estimate

\* Compiled from Chapter 10 on Services Sector in Economic Survey 2012–13, Government of India, Ministry of Finance, Economic Division. For more details see <http://indiabudget.nic.in>





**FIGURE 1.1** The service–product continuum

Services such as management consulting, health spas, and education have dominant service attributes. They form one end of the spectrum. Similarly, manufacturing and supply of machine tools, gadgets, and consumables have a dominant product attribute, and they form the other end of the spectrum. However, several businesses share both service and product attributes. Take the case of automobiles. There is a product attribute in it since it involves the physical structure of the passenger car. On the other hand, there is also the experiential component of using the car, which forms a significant part of the product. This is the service component. Similarly, in the case of a restaurant, the food items share both product and service attributes. There are certain important differences between services and manufacturing. Let us take a brief look at each of these differences.

### Intangibility

Fundamentally, services differ from manufacturing with respect to tangibility. Because services are experiences rather than objects, they cannot be touched, tasted or felt as in the case of objects. At the most, the recipients of services can form an opinion (based on some personal assessment) about the quality of the service offered. This has important implications for defining and assessing the quality of the service.

On the other hand, in a product-oriented operation, the product is defined by certain attributes and the customer faces less ambiguity with respect to the product, its attributes, and its performance. This is because the customer can touch and feel the product and make his/her own assessment of the product.

Fundamentally, services differ from manufacturing with respect to tangibility, heterogeneity, simultaneity, and perishability.

### Heterogeneity

The second differentiating aspect of services is the high degree of heterogeneity associated with them. Since the experiential component is dominant in a service, it is likely that no two services are exactly alike. The differences are attributed to the differences in the service receivers (customers), the service providers, and other parameters of the service delivery system. Therefore, a dentist attending to two consecutive patients having identical ailments may provide more or less the same type of service. Nevertheless, the two patients may have different perceptions of the quality of the service and may have different satisfaction levels. Moreover, the time spent by the dentist in both the cases could vary greatly. High heterogeneity results in high variability in the operations system performance and the need to factor them into the planning and control of operations.

High heterogeneity results in high variability in the operations system performance.



## Simultaneous Production and Consumption

More often, services occur in the presence of the customer, who may also be involved at the time the service is produced for his/her consumption. In the example of the dentist and the patient, the doctor and the patient are in the system together to produce and consume the service. This holds for education, entertainment, travel, tourism, and hotel services as well. In the case of manufacturing, however, most goods are produced at some point in time and distributed to the customer later. This difference has implications for the design, planning, and control of service operations, as the degree of customer contact in a service delivery system is likely to be high.

### VIDEO INSIGHTS 1.1

Operations management in service organizations have a different set of issues to address. In order to develop an understanding of the peculiar issues pertaining to operations management in service organizations, a peep into service systems will be a valuable exercise. Hospitality and Healthcare sectors of services face unique challenges arising out of people-intensive service delivery, where the customer involvement is also high. To understand the issues in these sectors, find the video links (Video Insights) in the Instructor Resources or Student Resources under section **Downloadable Resources** (<http://www.pearsoned.co.in/BMahadevan/>) subsections **Bonus Material**.

## Perishability

Services cannot be inventoried.

Services are perishable. This implies that they cannot be inventoried. Thirty minutes of a doctor's consulting expertise today cannot be stored for future use, reused, or returned in a future period. Similarly, the treatment for an acute headache likely to be faced by a patient sometime in the future cannot be stored in advance and reused at that time. The possibility of inventorying the supply and using it at a later time is very common in a manufacturing system. The implication for operations is that service systems require methods that work without inventories.

The characteristics of tangibility, heterogeneity, simultaneity, and perishability apply to "pure services," which are more experiential in nature. Furthermore, businesses with dominant service characteristics will have these features dominating over the other product-related features. For example, in the case of a fast-food joint, there is both the service aspect and the product aspect. A customer having a plate of *idli* with *sambar* experiences all the four attributes discussed here when viewed from the service angle. However, there is also a product angle to the restaurant. For instance, viewing *idli* as a product may enable the restaurant owner to inventory it for future use (later in the day).

### ideas at Work 1.2

#### Operations Management in Service Systems

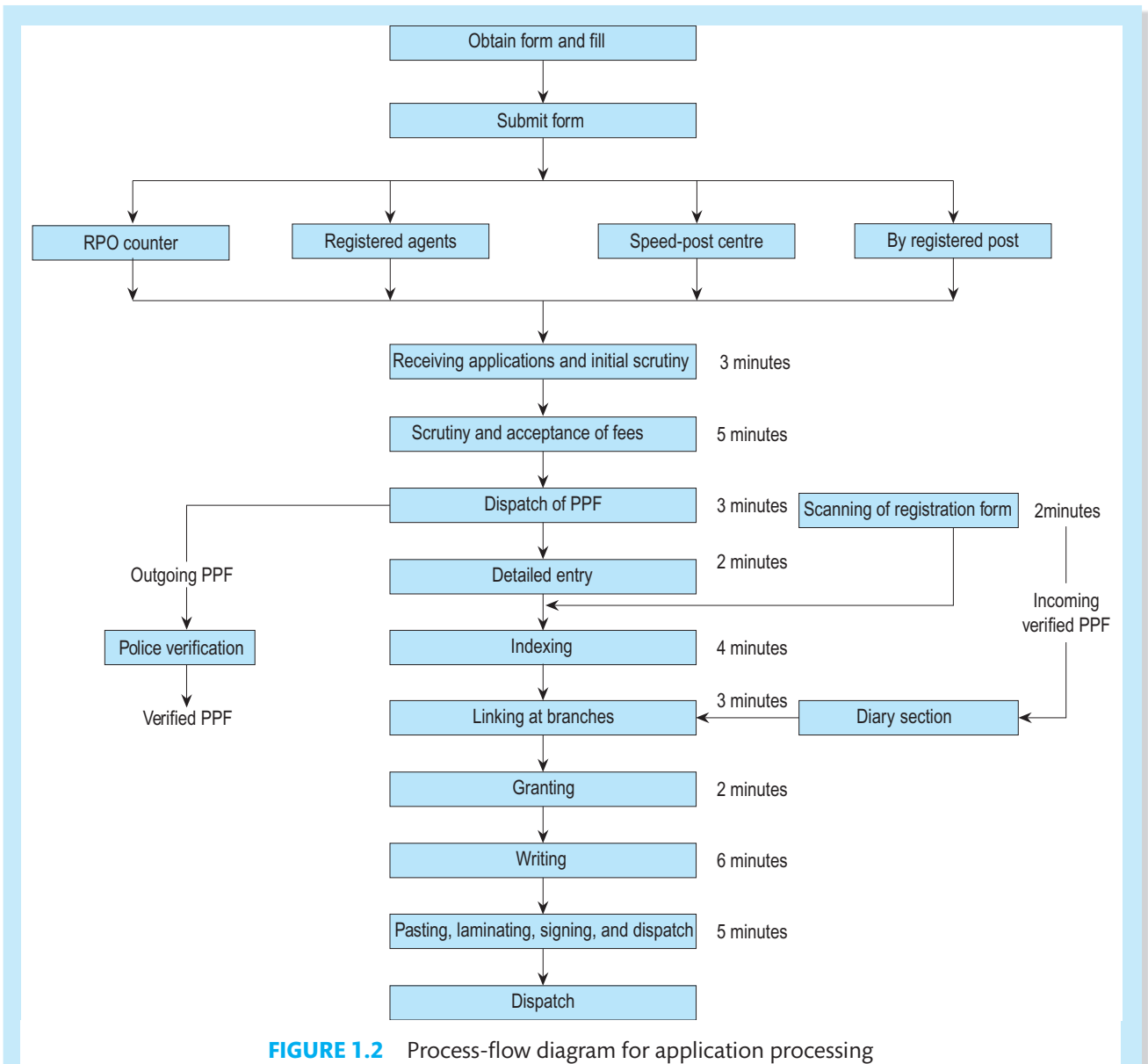
Intangibility, heterogeneity, perishability, and simultaneous production and consumption are the factors that differentiate service systems from manufacturing systems. Despite these differences, many of the operations management tools that were initially developed for manufacturing organizations are applicable to services as well. A study on the Ahmedabad Regional Passport Office (ARPO) illustrates this fact.

In March 2001, the regional passport officer of the ARPO was concerned about the long lead time taken for processing passport applications and issuing passports. The estimated lead time was 145 days at

that time, so there was always a long queue of applicants waiting at the ARPO, either to know the status of the application or to submit the application form. To improve the response time, the existing process needed to be studied and redesigned. The situation called for the application of the principles of operations management to a service setting.

A detailed study of the process was undertaken to investigate the reasons for the long lead time. Excessive delays and long lead times often point to operations management issues pertaining to capacity, process, procedures, and use of technology and people.





Process mapping, estimating the time for each step in the process, and assessment of capacity imbalances are important steps in studying issues related to long lead times in any operations system. In the case of the ARPO, this data was collected. Although the ARPO had a sanctioned staff of 103, the staff strength was 57 in January 2002. It augmented the capacity by employing 40 casual workers. It received about 235,000 applications in a year. Detailed studies were initiated to understand the various processes involved in issuing passports. See Figure 1.2

for an illustration of the process followed for passport application and approval.

Detailed discussions with the officers revealed several opportunities for improving the existing situation. The activities at the ARPO were labour-intensive, and the organizational rules and procedures were highly centralized. Further, the discussions revealed that there was scope for automation of some of the activities. In the present scenario, it took a lot of time to access information on the application status, and Web-based