DEDICATION
This one’s for Prof. Dr. Dundar Kocaoglu, Founding Chair and Professor Emeritus, Department of Engineering and Technology Management, Portland State University, Portland, Oregon, USA, and President and CEO, Portland International Center for Management of Engineering and Technology (PICMET).

Professor Kocaoglu retired this year after 40 years in academia. He was not just a professor giving courses, he gave students visions, supported them always and helped them starting a new chapter in their lives.

His PICMET conference has become an annual one, held at different locations in the world; bringing together experts and defining the directions of technology management for decades.

Dundar, thank your for your absolutely exceptional work on technology management and the traces that you left!

ACKNOWLEDGEMENTS
For the development of this publication thanks to the scientific team of ETCOP (DDr. Anna Stein, Dr. Siegfried Begun and their teams) for the excellently done project management and coordination with the board of reviewers.

Thanks to my Co-editor, Assoc. Prof. Dr. Birgit Oberer, for an excellent critical review and a well-defined quality assurance program implemented firstly for this volume of our Enterprise & Business Management series.

Special thanks to the honorary international board of reviewing professors from the USA, Canada, Switzerland, England and Austria.
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Innovation and Technology Transfer in EMEA Region – a Success Story from 1001 Nights 311
Effectively managing your organization involves many aspects, from day-to-day to large-scale events or maintenance, while managerial duties are often never ending. Solid leadership skills and an understanding of the industry are a great start, but these alone will not create solid management in your organization. What is needed? You need to study **Enterprise & Business Management**. Studying **Management** help you to understand theory and develop the skills to put it into practice but modern business is too complex to be covered by a single subject; modern managers need to have a broad outlook. It is needed to develop an awareness of **academic and practitioner perspectives** and apply them in real life settings.

Studying **Enterprise and Business Management** you should gain an understanding of **entrepreneurship**, by focusing on the examination of entrepreneurial processes, and its ability to change organizations, markets and whole societies. You have to focus on the concept of management **processes** and practices in global context, develop an understanding of the **management** theory and its relevance to **practice** and get an idea on which challenges managers face in today’s ever changing business environment.

**What to focus on?**

- Meet the needs of your customers
- Market your organization effectively
- Hire the ‘right’ person
- Train and motivate your employees
- Build your leadership
- Delegate effectively
In the current volume of our **Enterprise & Business Management series** we focus on the ‘five fingers’ of EBM, **TeSoKinSo**, which are

- **Te** Technology Management
- **So** Software Engineering
- **K** Knowledge Management
- **In** Innovation Management and
- **So** Social Media Management

These are the fundamentals of being successful in enterprise and business management.

Each ‘**lesson ticker**’ focuses on one of these fundamentals in detail and gives you a comprehensive overview on what is important to know.

Each **chapter** focuses on specific aspects of the five fundamentals, including **review questions, exercises** and **literature for further studies**.

Because of the international board of authors and their knowledge, the contributions reflect the international views on business as well as enterprise management topics. This provides the publication with specific international foresight in the area of business and enterprise management and a significant place to combine theory and practical research.

The editor wishes the reader a most informative and enjoyable reading

Alptekin Erkollar

December 2016
The 5 fingers of Enterprise and Business Management ...

Technology | Management
Software Engineering | Knowledge Management

Innovation Management | Social Media
Lesson Tickers

enriched with Lesson Tickers focusing on these trend topics
LESSON TICKER: TECHNOLOGY MANAGEMENT

Technological change is one of the most important sources of change in the economy. Technology consideration must be an integral part of a firm’s business strategy. With the increasing impact of globalization on business, the scope for competition is no longer limited by national boundaries or by the definition of a particular industrial sector. A sound scientific and technological base is essential to economic growth in a competitive international environment.

Definitions
To a **scientist** technology is the end product of research, while to an **engineer** technology is a tool or process that can be employed to build better products.

**Technology** refers to all the knowledge, products, processes, tools, methods, and systems employed in the creation of goods or in providing services.

The **management** function includes planning, organizing, coordinating and controlling. Innovation refers to new products, new processes, new managerial approaches, and combinations of the above.

The discipline
Management of technology is an interdisciplinary field of natural sciences, social sciences, business management, engineering.

Technology management supports organizations in finding answers to the following questions:
• How are technologies created?
• How can the dimension technology be integrated in a business strategy?
• How can technologies be used to gain competitive advantages?
• How can technologies be exploited to create business opportunities?

**Classification of technology**
Emerging technology, new technology, low technology, medium technology, high technology, appropriate technology.

**Relationship between business and technology**
The goal of an organization is to achieve a set of objectives. Technology adds value to the assets of a company.

**Business view on managing technologies**
New technologies require plans for system integration, qualified champions as well as organizational integration.
Challenges: lack of system integration, incompatible systems, failure of the champions and lack of cross-functional teams.

**Technology management and innovation**
The adoption and implementation of IT is an important aspect of innovation.

Variables to be considered with innovation are the ability to understand competitors’ innovative strategies, structure and cultural context, the business technological environment, strategic management capacity in dealing with entrepreneurial behavior and resource availability and allocation. Success factors of technology management are adaptability, business focus, sense of integrity, Hands-on top management, organizational cohesion and entrepreneurial culture. Leaders must have a strong knowledge and capability in managing both technology and people. Technology and human resources must be working in an integral manner to ensure success. Technology itself does not produce commercial results. It is its application that brings commercial benefits.
How to review technological innovation?
Discovery of a new idea or product or process, evaluation of the proposed idea or design concept, verification of the theory or design, demonstration of a prototype, evaluation, commercial introduction of the innovation, adoption.
Change in technology without change in the way it is used can lead to failure.

Technology transfer
Technology can be bought, sold, or lease.

Technology licensing
Inward and outward licensing deals with the issue of intellectual property.

Relationship between technology and market
Congruent of an innovation with corporate objectives and targets.
Proactive approach for technical developments.
Feasibility analysis of an innovation (technological and commercial view).
Balance between market pull and technology push.

How to choose technology management methodologies?
Which factors have to be considered?
The corporate maturity, the nature of the technology involved, corporate processes, best practices of the industry, industry wide risk acceptance rate, corporate learning capabilities.

Prerequisites for a successful methodology?
Management recognizes the need for the project and enables a flexible landscape for the project to grow up with.
Availability of clear defined core competences.
Willingness to provide and manage business functions that support the methodology (project management, personnel deployment, Mentor support).

People with innovative spirit are the main factor in using technology for development. They can ease both the technical development, and
the social one, they can assure the link between research-development, industry and decision factors and environmental factors. Technology transfer is developed through knowledge transfer.

**Benefits of using a methodology**
Consistent and standardized approaches, faster implementation and use, better planning, development of a knowledge base.

**When you have chosen a methodology review it consequently**
- Do we use the most appropriate methodology?
- How can flexibility be encouraged?
- Do project management and technology management properly match?
- Is the necessary administrative support provided?
- Do we build appropriate competences with the methodology applied?
- Is productivity optimized throughout the project life span?

**Strategic technology lifecycle**
The strategic technology lifecycle (TLC) offers a systematic approach for assessing the state of your technologies.

Steps to develop a TLC: Kick off => decide => deploy => manage => develop => support => use.

**How to increase competitiveness?**
Knowledge generators that would create new technologies.
Research results transferred to industry, market valued.
Transferable technologies towards the economic environment.
Intellectual property; patents.
Trained staff (technology brokers).
Knowledge transfer in universities—to the market.
Financing the innovation: venture capital, business angel.
Innovative SMEs with high added value.
Promotion, formation of a mass innovation culture.
Definitions

Software is the product that software professionals build and then support over the long term. Software encompasses (a) instructions, function, and performance, (b) data structures that enable the programs to adequately store and manipulate information and (c) documentation that describes the operation and use of the programs.

Software engineering is concerned with theories, methods and tools for professional software development. It is the science and art of building significant software systems that are on time, on budget, with correct operations and with acceptable performance. Software costs often dominate system costs; software costs more to maintain than it does to develop. Software engineering forms a bridge from customer needs to programming implementation. Software engineering is concerned with cost-effective software development.

‘Software Engineering: (1) The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software. (2) The study of approaches as in (1).’ IEEE definition.
Stakeholders
A customer requires a system to achieve some business goals by user interaction or interaction with the environment in a specific manner. Software engineers have to (1) understand how the system-to-be needs to interact with the user or the environment so that customer requirements are met and (2) design the software-to-be. The programmer has to implement the software-to-be designed by the software engineer.

Software products
1. 1:1 developed products: systems which are commissioned by a specific customer and developed specially by some contractor.
2. 1:N developed (generic) products: Stand-alone systems which are produced by a development organization and sold on the open market to any customer.
3. M:N (hybrid) systems: generic products sold as stand alone, customized according to customer needs.

Software product evaluation criteria
Maintainability, dependability, effectiveness, efficiency, usability, hybridness.

The relative importance of these evaluation criteria (attributes of software products) depends on the product and the environment in which it is to be used. In some cases, some attributes may dominate.

Software engineering focuses on a layered technology, based on the layers (a) quality focus, (b) process, (c) methods and (d) tools.

Process layer as the foundation defines a framework with activities for effective delivery of software engineering technology. Method provides technical how-to's for building software. Tools provide automated or semi-automated support for the process and methods. The quality focus is the general commitment of an organization to quality which fosters a continuous process improvement culture.
# Attributes of good software

<table>
<thead>
<tr>
<th>Maintainability</th>
<th>Software should be written in such a way so that it can evolve to meet the changing needs of customers. This is a critical attribute because software change is an inevitable requirement of a changing business environment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>Software should not make wasteful use of system resources such as memory and processor cycles. Efficiency therefore includes responsiveness, processing time, memory utilization, etc.</td>
</tr>
<tr>
<td>Acceptability</td>
<td>Software must be acceptable to the type of users for which it is designed. This means that it must be understandable, usable and compatible with other systems that they use.</td>
</tr>
<tr>
<td>Dependability and security</td>
<td>Software dependability includes a range of characteristics including reliability, security and safety. Dependable software should not cause physical or economic damage in the event of system failure. Malicious users should not be able to access or damage the system.</td>
</tr>
</tbody>
</table>

## Software applications

- System software: compilers, editors, file management utilities
- Application software: stand-alone programs for specific needs
- Engineering software: Characterized by ‘number crunching’ algorithms
- Embedded software: resides within a product or system
- Product-line software: focus on a limited marketplace to address mass consumer market.
- Web applications: network centric software.
- Artificial Intelligence (AI) software: uses non-numerical algorithm to solve complex problem.

## Software development process

Structured set of activities required to develop a software system (specification, design, validation, evolution), which vary depending on the organization and the type of system being developed.

## Software development methods

- waterfall
- iterative
- incremental
- agile
- hybrid

**Classification of software process models**

**Generic software process models**
Waterfall: Separate and distinct phases of specification and development.
Evolutionary: Specification and development are interleaved.
Formal Transformation: A mathematical system model is formally transformed to an implementation.
Reuse-based: The system is assembled from existing components.

**Engineering process model**
Specification: Set out the requirements and constraints on the system.
Design: Produce a model of the system.
Manufacture: Build the system.
Test: Check the system meets the required specifications.
Install: Deliver the system to the customer and ensure it is operational.
Maintain: Repair faults in the system as they are discovered.

**Hybrid process models**
Large systems are usually made up of several sub-systems. The same process model need not be used for all subsystems. Prototyping for high-risk specifications. Waterfall model for well-understood developments.

**Spiral model**
Focuses attention on reuse options. Focuses attention on early error elimination.

Puts quality objectives up front. Integrates development and maintenance.
Provides a framework for hardware/software development.
Contractual development often specifies process model and deliverables in advance.
Requires risk assessment expertise.
Potential problems of process models

<table>
<thead>
<tr>
<th>Process Model</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterfall</td>
<td>High risk for new systems because of specification and design problems.</td>
</tr>
<tr>
<td></td>
<td>Low risk for well-understood developments using familiar technology.</td>
</tr>
<tr>
<td></td>
<td>Unidirectional, no way back, finish this step before moving to the next.</td>
</tr>
<tr>
<td>Prototyping</td>
<td>Low risk for new applications because specification and program stay in step.</td>
</tr>
<tr>
<td></td>
<td>High risk because of lack of process visibility.</td>
</tr>
<tr>
<td>Transformational</td>
<td>High risk because of need for advanced technology and staff skills.</td>
</tr>
</tbody>
</table>

Process visibility

Software systems are intangible so managers need documents to assess progress.

Waterfall model is still the most widely used model.

<table>
<thead>
<tr>
<th>Model</th>
<th>Visibility</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterfall</td>
<td>good</td>
<td>Each activity produces some deliverable</td>
</tr>
<tr>
<td>Evolutionary</td>
<td>poor</td>
<td>Uneconomic to produce documents during rapid iteration</td>
</tr>
<tr>
<td>development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formal transformations</td>
<td>good</td>
<td>Documents must be produced for each phase of the process to continue</td>
</tr>
<tr>
<td>Reuse-oriented</td>
<td>moderate</td>
<td>Sometimes artificial to produce documents describing reuse and reusable components</td>
</tr>
<tr>
<td>development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spiral model</td>
<td>good</td>
<td>Each segment of the spiral should produce some document</td>
</tr>
</tbody>
</table>

Unified modeling language (UML) to understand the problem domain

- System to be developed
- Actors
- Agents external to the system
• Concepts/Objects
• Agents working inside the system
• Use Cases
• Scenarios for using the system

Software measurement
What to measure?
• Project (developer’s work), for budgeting and scheduling
• Product, for quality assessment

Software engineering in practice
1. Understand the problem (communication and analysis):
   - Who has a stake in the solution to the problem?
   - What are the unknowns?
   - Can the problem be compartmentalized?
2. Can the problem be represented graphically?
   - Plan a solution (modeling and software design)
   - Have you seen similar problems before?
   - Has a similar problem been solved?
   - Can sub problems be defined?
   - Can you represent a solution in a manner that leads to effective implementation?
3. Carry out the plan (code generation)
   - Does the solutions conform to the plan?
   - Is each component part of the solution provably correct?
4. Examine the result for accuracy (testing and quality assurance)
   - Is it possible to test each component part of the solution?
   - Does the solution produce results that conform to the data, functions, and features that are required?
### Questions on Software engineering

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is software?</td>
<td>Computer programs, data structures and associated documentation. Software products may be developed for a particular customer or may be developed for a general market.</td>
</tr>
<tr>
<td>What are the attributes of good software?</td>
<td>Good software should deliver the required functionality and performance to the user and should be maintainable, dependable and usable.</td>
</tr>
<tr>
<td>What is software engineering?</td>
<td>Software engineering is an engineering discipline that is concerned with all aspects of software production.</td>
</tr>
<tr>
<td>What is the difference between software engineering and system engineering?</td>
<td>System engineering is concerned with all aspects of computer-based systems development including hardware, software and process engineering. Software engineering is part of this more general process</td>
</tr>
<tr>
<td>What is the difference between software engineering and computer science?</td>
<td>Computer science focuses on theory and fundamentals; software engineering is concerned with the practicalities of developing and delivering useful software.</td>
</tr>
</tbody>
</table>
Knowledge management (KM) is the process through which organizations generate value from their intellectual property and knowledge-based assets. It involves the creation, dissemination, and utilization of knowledge.

Discipline within an organization that ensures that the intellectual capabilities of that organization are shared, maintained and institutionalized.

The process of systematically and actively managing and leveraging the stores of knowledge in an organization.

Refers to an entire integrated system for accumulation, integration, manipulation, and access of data across multiple organizations.

The way a company stores, organizes and accesses internal and external information.

*Knowledge Management is the explicit and systematic management of vital knowledge - and its associated processes of creation, organization, diffusion, use and exploitation.*

**Knowledge generation**

Data => information => knowledge
Knowledge classification

**Tacit knowledge:** This type of knowledge exists in people's heads, not articulated or documented

**Explicit knowledge:** This type of knowledge can be processed by information systems, codified and recorded and archived and protected

Transforming knowledge

**Tacit to Tacit**
E-meetings, synchronous collaboration (chat)

**Explicit to Tacit**
Visualization, browsable video/audio of representations

**Tacit to Explicit**
Answering questions, annotations

**Explicit to Explicit**
Text search, document categorization

Knowledge management components

strategies - processes - metrics

Strategies, processes and metrics

Strategy: Motivation for knowledge management and how to structure a knowledge management program.

Process: Use of knowledge management to make existing practice more effective.

Metrics: Measure the impact of knowledge management on an organization.

How to develop a knowledge strategy?

Making known the knowledge that already exists by sharing best practices

Innovation: Convert ideas into products, services, improved business processes

Knowledge levers: Customer knowledge, knowledge in people, products, services, processes, relationships, organizational memory, knowledge assets
Link Knowledge strategy with business one

**Knowledge management architecture**
Access to both internal and external information sources
People who facilitate, curate, and disseminate knowledge within the organization
Information technology to provide automation support for many of the above activities
Repositories that contain explicit knowledge
Processes to acquire, refine, store, retrieve, disseminate and present knowledge
Organizational incentives and management roles to support these activities

**Aspects of Secure Knowledge Management**
Protecting the intellectual property of an organization
Security for process/activity management and workflow (users must have certain credentials to carry out an activity)
Access control including role-based access control
Risk management and economic tradeoffs
Digital rights management and trust negotiation
Composing multiple security policies across organizations
Security for knowledge management strategies and processes

**Security Strategies**
Policies and procedures for sharing data
Protecting intellectual property
Should be tightly integrated with business strategy

**Security processes**
Secure workflow
Processes for contracting, purchasing, order management, etc.
Metrics
What is impact of security on number of documents published and other metrics gathered

Techniques
Access control, Trust management

Knowledge management cycle
Knowledge creation - sharing - measurement - improvement

Knowledge management technologies
Expert systems - collaboration systems - trainings systems - web

People and systems

People
Knowledge Teams - multi-disciplinary, cross-functional
Learning Organization - personal/team/org development
Corporate Initiatives—chief knowledge officer

Systems
Knowledge Data-bases - experts, best practice
Knowledge Centers - hubs of knowledge
Technology Infrastructure - Intranets, Domino Document Management

Two ways to generate and use knowledge
- sharing existing knowledge ‘Knowing what you know’
- knowledge for innovation ‘Creating and converting’

Knowledge cycle
Create - identify -collect - classify - organize/store - share/disseminate - access - use/exploit - create ...

Knowledge management has exploded due to the web and has different dimensions (technology, business, goal is to take advantage of knowledge in a corporation for reuse, services will play a key role in technology). Tools are emerging, effective partnerships between business leaders, technologists and policy makers are needed. Knowledge management may subsume information management and data management.
Lesson ticker: Knowledge Management

Levers
Customer knowledge - the most vital knowledge
Knowledge in people - but people ‘walk’
Knowledge in processes - know-how when needed
Knowledge in products - ‘smarts’ add value
Organizational memory - do we know what we know?
Knowledge in relationships - richness and depth
Knowledge assets - intellectual capital

Implementing and maintaining knowledge management
- Why to implement knowledge management?
- Who’s responsible?
- IT’s role in implementing?
- strategy for implementing?
  a) macro environment
   i. globalization
   ii. technology
   iii. E-companies
  b) organizational climate
   i. Structure
      1. formal structure
         Cross functional project groups
         Cross-discipline learning groups
      2. Informal structure
   ii. strategy/goals
   iii. culture
  c) technical climate
   i. infrastructure
   ii. response to change
  d) technical, informational, personal
   i. technical
      system standardization
      compatibility
      usability
   ii. informational
   iii. Personal
knowledge roles
motivation
learning networks
• maintaining knowledge management system

Principles of effective learning
understanding
Mental models, paradigms, context, observation, assumptions, opinion, fact, truth
systems thinking - variation

skills
Ability to challenge assumptions
Listen to understand

processes
Complete observe, assess, design, implement, cycle
Teach others

The goal of knowledge management metrics
Measuring success (How am I doing?)
Tracking improvement (Am I getting better?)
Benchmarking (How am I comparatively doing?)
Strategy
Alignment (culture, incentives)
Direct future investment (technology, employees)

Knowledge sharing metrics
Number of presentations made
Number of improvement suggestions made
Number of web page hits
Number of patents approved
Number of members in discussion lists
Number of subscriptions to journals
Number of shared documents published
Number of times advice is sought
Number of conferences attended
Number of contacts made

**Incentive based approaches of knowledge management**

**Positive incentives:**
Receiver: Knowledge gained, can teach others what is learned
Teacher: “Knowledge Transfer Champion” prestige

**Negative incentives:**
Receiver: time, unqualified teacher
Teacher: time, students not willing to learn

**Theory on organizational knowledge management**
- dimensions of knowledge creation
  - Ontological: knowledge is created by individuals not about individuals
  - Epistemological: humans create knowledge by involving them with objects
- Knowledge Conversion: Interaction between Tacit and Explicit knowledge
  - Socialization: tacit to tacit
  - Externalization: tacit to explicit
  - Combination: explicit to explicit
  - Internatlization: explicit to tacit

**Knowledge management in process management**

**Types of processes**
- Simple processes: Low level operation
- Complex and nonadapative processes: Systems that sue the same rules
- Complex and adaptive: Agents carrying out the processes are intelligent and adaptive

**Data mining for knowledge management**
Data Mining is a key technology for knowledge management
Mine the data to determine the competitor strategy to improve business; also to enhance one's own strategy
Targeted marketing to customers to improve sales
Determine strategies for employee retention and benefits

Knowledge resource exchange
The challenge is create value through alliances and collaborations
The partner resource exchange model:
The concepts can be extended to include multiple partners and multiple dimensions
Definitions
Innovation is an opportunity for something new, different. It is always based on change. Innovators do not view any change as a threat but as an opportunity.

Technological innovations are defined as new products and processes and major technological modifications to products and processes. An innovation is considered performed if it is introduced to the market (product innovation) or implemented in the production process (process innovation). Innovation includes many research, technological, organizational, financial and commercial activities.

Types of innovations

Product innovation
A good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics.

Marketing innovation
A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

Organizational innovation
A new organizational method in business practices, workplace organization or external relations.
Process innovation
A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.

Degree of novelty as an indicator for innovation
Incremental innovation
Radical innovation
Systemic innovation
All innovations can be done on system or component level.

Characteristics of successful innovating companies
Creativity of employees
Good team work
Continued education of employees
Employees’ motivation

Systematic collection of all impulses that could lead to innovation
Project-based approach and ability to manage projects
Proper rate of risk-taking
Ability to evaluate the possibility of the innovation idea
Ability to finance the innovation activities
Cooperation with external experts

Innovation categories
sustaining—better products that can be sold with higher margin to demanding customers; incumbents win, focused on demanding customers; both incremental and radical. Incumbents have resources and motivation.

disruptive—commercialization of simpler, more user-friendly products, which are cheaper and targeted to new or less demanding customers; new entrants win, introduce products and services not as advanced as existing ones, but offering other advantages

Key elements of disruption
Customers at each market have limited absorption capacity, technological progress is faster that the ability of the market to employ it, companies
focus on better products to be sold with higher margin to unsatisfied customers.

**Closed innovation - requires control**

All the best people are working for us

Winner is who gets the innovation to the market first. If we develop the product

ourselves, we will be the first on the market. R&D creates profit only when we invent, develop and market everything ourselves.

We will win if we develop most of the ideas (an the best of them).

**Open innovation**

companies use external as well as internal ideas and both external and internal ways to market, internal ideas can be taken to the market through external channels to generate additional value.

*Not all the best people are working for us*. We must work with clever people within and outside our company.

*R&D can create profit even if we do not initialize and perform it ourselves.*

We will win if we make best use of internal and external ideas.

*To develop better business model is more important than to be the first in the market.*

*External R&D can create remarkable value; to employ it, we need absorption capacity, often as internal R&D.*

*We must be able to profit from others using our intellectual property and we must license the intellectual property if it supports our business model.*

**Innovation potential of an organization**

An organization with high innovation potential scores high in the following areas:

1. Strategy and planning,
2. Marketing,
3. Technological process,
4. Quality management,
5. Logistics,
6. Human resources.

For an organization, it is important to know its innovation potential.
(1) **Strategy and planning**: Idea about the organization’s future, vision and employees, company innovation programs, plan modifications, financial indicators of the plan, project management

(2) **Marketing**: Monitoring of current market trends, evaluation of the market competition position, customer-orientation, monitoring of customers’ attitudes to the company product, market information flow inside the company, marketing and financial control

(3) **Technological process**: Future company’s competitiveness in the industry, changes of technologies, collection of impulses for implementation of technology changes, evaluation of the return on investment, calculation of production costs and their monitoring, creation of resources for development

(4) **Quality**: Monitoring of changes conditioning the quality management in the company, employees’ personal contribution to the quality system, external quality audit in the company, monitoring of the environmental impact, impact of quality monitoring on the company processes, covering of costs resulting from modifications of standards, regulations and legislation in the sphere of quality and environment

(5) **Logistics**: Organization of purchase and distribution channels in the company, optimization of the company logistics, information and communication flows between the company and its partners, flexibility of logistics processes, introduction of innovations in logistics, logistics and financial control

(6) **Human resources**: Employees satisfaction, employees motivation, management and communication, conflict resolution, company information system, company culture

**Change as a driver for innovation**

**Categories of change**: people, structure, technology

**External forces of change**: competition, economic conditions, government programs, technology

**Internal forces of change**: internal operations, impact of external effects

**Agents of change**: managers, staff specialists, outside consultants
Techniques for reducing resistance to change: education and communication, participation, negotiation, manipulation, coercion, support

Techniques for managing change
- structure: authority, coordination, centralization
- technology: processes, methods, equipment
- people: attitudes, expectations, behavior

Organizational development techniques
- inter-group development
- process consultation
- survey feedback
- team building

Organizational stress factors
Task demands, role demands, interpersonal demands, structural dimensions, leadership techniques

Creativity and innovation
What is creativity?
Combining new ideas in unique ways or associating ideas in unusual ways

What is innovation?
Turning creative ideas into useful products, services, or methods of operation

The creative process
Perception, incubation, inspiration, innovation

Sources of innovation
- structural variables
- organizational culture
- human resources

Sources of innovation impulses

General approach
Own R&D
Technical divisions—design, technology
Production divisions (production, provision of services)
Logistics (purchase and supplies)
Marketing and sales

**Drucker approach**

1 Internal factors
1.1 unexpected event
1.1.1 Unexpected success
   - What will the use of the offered opportunity mean to us?
   - Where will its introduction take us?
   - What do we need to do for its implementation?
   - How can we achieve that?
1.1.2 Unexpected failure
1.1.3 Unexpected external event
1.2 Contradiction: Non-compliance with economic reality, contradiction between reality and anticipations about it, contradiction between the anticipated and real behavior of customers and their values
1.3 change of work process: realize the necessity of change, identify the weak point of the chain, be convinced that if something does not work the way it should, then it is necessary to attempt a change, the solution must be convenient for those who will implement it. It must place moderate and feasible requirements
1.4 change in the structure of industry or market: rapid growth of the industry, identification of new market segments, convergence of technologies (e.g. use of computers in telecommunications), rapid change of the industry and resulting need of a structural change

2 External factors
2.1 demographic changes
2.2 changes in the world view
2.3 new knowledge

**Market pull**

improvement of the existing products, extension of the existing offer or decrease of price
impulses for continuous, incremental innovations or for process innovations
looking for the best way of satisfying a newly emerging customer demand

**Research and development push**
generating of new markets for conceptually different products
looking for commercial use of new impulses resulting from the R&D results

**Impulses from market environment**
1. Customers
   product presentation (realistic, simple, demonstrative and precise, moderate, representative sample of customers)
2. Suppliers
3. Competitors

**Impulses from Research & Development (R&D)**
1. identification research: to monitor the scientific, technical and economic information and identify innovation impulses applicable in the company
2. basic research
3. applied research: acquire knowledge and means applicable for the meeting of specific, beforehand-defined goals
4. development: systemic use of knowledge and means acquired in the applied research for the creation of a new or improvement of the existing product or for the creation or modification of processes

**Internal impulses**
usually combined with external sources; supported by creative techniques and innovation tools

**General innovation tools**
- value analysis
- brainstorming
- business process reengineering
- benchmarking
- change management
- technology forecasting
- technology audit

**Managerial innovation tools**
- peer evaluation
- team building
- effect analysis

**Process innovation tools**
- lean thinking
- just in time approach
- concurrent engineering
- continuous improvement
What is social media?
Any online tool that helps you connect and engage with your clients, students, or public. Social media enables organizations to maintain daily contact with their online audience, creates opportunities for conversations and collaborations with visitors and other organizations. In order to streamline outward-facing social networks, social media management should be employed, to see all your social networks in one place.

Before you begin to use social media you should ask the following questions:

- Do we already have one?
- Do we really need one?
- Who will manage and maintain it?
- Is there time to maintain it?
- What kind of account to use?

Why you need a social media policy and project plan?
Provide guidance for using social media to communicate about your organization, clarify the relationship between existing policies and contemporary uses of social media, provide a structure for future social media endeavors and clarify work-related and personal uses of social media.
How to develop a social media strategy?
• business mission
• business goals
• department goals
• social media goals
• social media tactics
• social media tactics

Goal setting
awareness- consideration - preference - visit - advocacy

Phase 1: now-3 months
• calls to action
• engagement vs. Narration
• cross-channel integration

Phase 2: 3–12 months
• uniform brand
• search optimization
• mobile optimization
• blog/content

Phase 3: 12 months on
• clear and direct customer journey
• audience optimized
• intuitive usability

What to consider?
What are the goals you hope to achieve by using social media? What are the reasons your social media use will complements our overall strategic plan? What are the types of content you’ll provide and the types of content you’ll solicit from your community? What are the performance outcomes? How will you know if it was worthwhile developing this? Who is/are the intended audience(s)? Age? Profession? Internal or external? Special interests? Who are the individuals authorized to speak on behalf of your organization?
How to create meaningful connections with audience?
Use a friendly voice in your posts, create and encourage conversations, ask your followers questions, respond to your followers, do not leave questions unanswered, prompt and friendly communication will result in audience members feeling a sense of importance and belonging to your organization, know your collections and subject matter, post what is relevant to the lives of your audience members.

Types of posts
Cross-Media Posting: Post important articles and news across all of your social networks simultaneously.
Schedule posts: Draft posts for the future.
Auto-Scheduling: Designates post upload time depending on when your social network receives highest volume of traffic.

Social media analytics
Understanding the popularity and outreach of your social networks is vital. Use this data when composing your future posts.

Social media strategies
Understand the value of social media
Develop your social media brand
Create a social media team
Employ a social media manager
Document social media goals
Use a brand strategy for social media
Determine your visuals
Establish and document repeatable, efficient social media processes
Establish and document standards regarding how content is published and monitored
Decide what and when to post on social media
Measure and evaluate (check metrics)

Social Media Marketing is an effective, free way to communicate with your members, and gain new members by advertising your group and your events online. This form of marketing allows you to cultivate
your outward-facing image and engage with your audience and your members. Not only is it effective, but it provides quantifiable data that explains why your marketing techniques and outreach attempts are not working.
LEARNING OBJECTIVES
The software systems development is a complex socio-technical process containing cognitive, managerial, organizational, and technological challenges. However, researchers are versed at addressing phenomena in isolation, e.g., within a function, role, or view. Every so often new methods or models get adopted that place our reliance on new panaceas, but different organizations have different needs and make different choices. They make decisions about core issues, such as product architecture and concept, and project schedule, staffing, and strategy. After reading this chapter, the reader should be able to recognize the importance of approaching software systems development projects in their totality.

CHAPTER OUTLINE
Software systems development projects have been difficult to succeed in. The environment is dynamic, and exposed to risks that originate from many sources, including management. The project manager must assess the environment, develop a strategy and vision to succeed, communicate these to the stake-holders to buy into, and be forthcoming. An effective strategy and vision must factor in all the important variables, i.e., personnel, structure, task, and technology, and must be malleable and operationalized by various means. To investigate these, we attended two concurrent medium scale projects for the purpose of developing two nearly identical software systems for the same customer. The two
projects performed very differently, which was not simply due to different starting positions. In this qualitative empirical study, we focused on the effects of stakeholders’ abilities, knowledge, and skills on strategy, vision, and other factors, such as the application of technology, decision making, influence, insight, leadership, learning, and project control. The managerial involvement in the projects, the problem identification and understanding, and the strategies to overcome them, were all very different, which led to a surprising outcome. The results of this research suggest that the differences in the capacity of managerial involvement and strategizing were critical for the projects’ outcome.

**KEYWORDS**
Strategy, software, project management, learning, knowledge, experience

... numbers do not mean anything to me... there are so many guys who should have had titles, but do not have titles... because the numbers; we are so given over to this tyranny of stats in American sports today that we fail to look at who has the greatest impact when the [NBA] championship is on the line.

Mike Wilbon, ESPN, April 22, 2012

1 Introduction
Software engineering has been a rapidly progressing discipline, but has remained human and knowledge intensive, and with many challenges, such as an inability to make estimates with certainty, as well as to learn from or recognize one’s own mistakes, or those experienced by others. More specifically, the development of software systems is a socio-technical process containing cognitive, managerial, organizational, and technological challenges. These have been recognized early on as often being difficult to anticipate, and assess for impact. For instance, discussions at a conference back in 1968 covered all aspects of software development, including the difficulties of meeting schedules and specifications on large software projects, as well as the education of software (or data systems) engineers (Naur and Randell 1969). To better understand various aspects of software engineering, there have been studies of real world phenomena, but their impact has been weaker than in other disciplines (Perry et al. 2000), and some have suggested a lack...
Empirical studies play a fundamental role in modern science, and many analyses and surveys of the software industry and its practices have been published (Sjøberg et al. 2007). Typically, one selected aspect or factor has been captured and investigated. For example, it was found that since the first wave of estimating tools, development environments have changed so little that the models and their predicted environments are still valid today (Jensen et al. 2006); that culture, personalities, or skills affect team performance (e.g., (Chan et al. 2008), (Karn and Cowling 2006), (Müller et al. 2009)); that project management skills affects a project’s outcome (e.g., Chen et al. 2009); and that systems development activities are based on alliances among the interested parties (Brooke and Maguire 1998). The problems of designing large software systems were analyzed by using a layered behavioral model, and the importance of individual talent was emphasized (Curtis et al. 1988), but without insights on how a project manager can close the gap between the capability of personnel and the technical challenge, which has been the case even in mainstream literature (e.g., Pressman 2009).

These issues motivated our research, which includes a broader interest so that we can better understand what factors affect and characterize medium scale software development projects throughout their lifecycle. Team projects are dynamic organizations characterized by four strongly interdependent variables (i.e., personnel, structure, task, and technology (Leavitt 1965)). A change of state in one variable forces other variables to adjust and dampen out the impact (Keen 1981). The variables are complex entities that comprise many factors that characterize socio-technical systems, including communication, complexity, experience, knowledge, learning, method, motivation, personal judgment, resources, risk, skills, strategy, and workplace politics. To steer projects as planned, project managers control these factors. For example, a design can be selected that will minimize the risk of specific errors; a project plan can be used to bolster communication and teamwork among engineers; and a prototype can be built when dealing with an unfamiliar domain or technology. Organizing and strategizing are constants in managerial work that utilize similar hands-on skills and techniques so as to
accomplish change or improve a respective design (Whittington et al. 2006).

We believe that these factors are best monitored in vivo for their dynamics and effects so that one can better qualify the attributes, such as avoidable, clear, difficult, experienced, good, poor, and size, that have been used in literature (e.g., Keil et al. 2003). Herein, we present a longitudinal and qualitative empirical study that followed a software systems development program that consisted of two concurrent reengineering projects for an internal customer. Two in-house IT divisions were responsible for the projects, and other in-house divisions and teams also contributed. They all used the same managerial and quality procedures, and both projects used the same technology. From a system requirements viewpoint, the projects appeared nearly identical in complexity, scope, and size, and, consequently, the systems they were developing were nearly identical. The time frame for the program was nine months, which included the full software lifecycle and a period of two to three months for the live testing, but the initial plan for the whole program made the tasks for the two projects different. One project used its first month to recruit personnel and set up a development environment. The plan for that project was to reuse work products from the other project, which would reduce the cost of development and maintenance.

The reuse plan never eventuated, but the organizational behavior and mindset due to the reuse strategy persisted after the plan changed (e.g., the supplementary knowledge transfer in which the contributing teams with dissimilar knowledge could facilitate their mutual performance (Buckley et al. 2009) remained scant and unilateral). The plan change made the projects directly comparable, and we observed major differences in the factors important for these projects. At the start of the program, the newly recruited team completely lacked application domain knowledge, but had solid solution domain competence. The other team had strong application domain knowledge and ties, but poor solution domain competence. Eventually, the former by far outperformed the latter. A project manager with both managerial and software systems background outperformed a much more experienced project manager who built his career in the environment, but lacked the software competence. In short, the outcome and the problems
experienced by the project teams suggest a somewhat different course of events and sources of problems, and their ultimate impact on work performance and quality than previously reported by researchers.

Clearly, engineers and managers alike should be ready to step in and take on tasks that require different skills at different times. They should be able to make decisions and take initiatives that may cross the boundaries of their own, strict areas of responsibility in order to help their teams out and make their projects as successful as possible. These roles do not exist in isolation but are intricately intertwined, and depend on mutual adjustments. We find that the project managers, as the leaders, played a role that ultimately affected the performance and decided the outcome of these two projects. Their different mental models, characterized by their individual belief system, observability, and predictive power towards a target system (Norman 1983), caused them to see different opportunities, strengths, threats, and weaknesses, to make a very different judgment, and to seek different resolutions for problems that occurred on their respective projects. In other words, practice is central to understanding work, and the acquisition of knowledge and social identities at work (Brown and Duguid 2001), but achieving that is circumstantial. Below, we continue with a review of the research background, followed by a description of the program environment, developmental phases, a self-assessment, and an analysis thereof.

2 RESEARCH BACKGROUND

An influential survey of industry reported that software development projects’ failure ratio stands at 68% (Standish Group 2009). The survey reflects IT executives’ judgment and perceptions regarding project measures (see Table 1). Some authors opposed the survey altogether (e.g., (Eveleens and Verhoef 2010), (Glass 2005)), whereas a recent study found that the benefits of user participation had been conditional (Batenburg and Koopman 2010). On the other hand, it has been long known that people in organizations find themselves hard pressed either to find actual instances of rational practices or to find rationalized practices whose outcomes have been as beneficent as predicted, or to feel that those rational occasions explain much of what goes on within the organization (Weick 1976). Nevertheless, it is interesting to notice
that the first three criteria in Table 1 were found outside the projects, and the next three are project management-related. The staff related criteria weighed in at only 11% (i.e., 8 + 3). A similar European study of 214 projects in 10 major sectors of economy found that only one in eight projects was successful (McManus and Wood-Harper 2008).

Table 1  The success criteria for software projects according to CHAOS

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>1. User involvement</td>
<td>19%</td>
</tr>
<tr>
<td>2. Executive management support</td>
<td>16%</td>
</tr>
<tr>
<td>3. Clear statement of requirements</td>
<td>15%</td>
</tr>
<tr>
<td>4. Proper planning</td>
<td>11%</td>
</tr>
<tr>
<td>5. Realistic expectations</td>
<td>10%</td>
</tr>
<tr>
<td>6. Smaller project milestones</td>
<td>9%</td>
</tr>
<tr>
<td>7. Competent staff</td>
<td>8%</td>
</tr>
<tr>
<td>8. Ownership</td>
<td>6%</td>
</tr>
<tr>
<td>9. Clear objectives (goals) and vision</td>
<td>3%</td>
</tr>
<tr>
<td>10. Focused and hardworking staff</td>
<td>3%</td>
</tr>
</tbody>
</table>

Many factors, originating from different areas, can cause software development projects to fail (Charette 2005). For example, avoidable rework consumes 40–50% of developers time, business factors (e.g., competition and the need to cut costs), project size (e.g., large-scale projects fail three to five times more often than small projects because greater complexity increases the possibility of errors), sloppy development practices, and bad decisions by project managers due to tradeoffs that must be made based on fuzzy or incomplete knowledge (e.g., cost and duration estimating, and picking the wrong type of contract—all of which are as much art as science). A research goal of
this empirical study is to investigate how such factors can be anticipated, identified, and avoided or overcome in the practice of software systems development.

Deming cautions that quality is everyone’s business (Deming 2000). Organizations should institute leadership and training, and stop making too many optimistic assumptions about what personnel can do and know. The quality of collective and individual learning is a key determinant of organizational success (Hayes and Allison 1998), so that all members of an organization must be involved in continuous learning and take action to make improvements (Weldy and Gillis 2010). For example, management is not simply problem solving but related to creation (Kofman and Senge 1993), and organization design is generally an outcome, not an input (Cherns 1976). Software systems are complex and utilize various technologies and personnel with a different expertise. The need for new approaches and methods, new ways of organizing the development work, etc., has been recognized (Carstensen and Vogelsang 2001). It is possible to produce software of the highest quality and at a significantly lower cost, which is contingent, among others, on our ability to anticipate, identify, and fix problems, as well as manage change and risk (de Gyurky 2006). Capabilities and knowledge are central to strategy (Westney 1995). The incompetence of managers and other organizational behavior issues are the main reasons for excessive development cost and time, and poor quality. If the manager is the architect of both the organization and the system that is going to build the best possible product on budget and on time (de Gyurky 2006), then the management knowledge items (i.e., the estimates, quality, risk, schedules, and staffing plans (Birk et al. 1999) are too narrowly defined.

The process of software development is neither formal nor mechanical but creative and social, with learning an important part of it, which means that education, experience, and training, for example, all contribute to a person’s ability to manage risk (Hall 2003). Every human estimator draws upon his or her background of domain knowledge, education, experience, and technical knowledge in formulating an estimate (Boetticher et al. 2006), yet much IT project learning could be incorrect (Jørgensen and Sjoberg 2000). Since knowledge encompasses emergent characteristics that stem from situated and largely unplanned activities and decision-making (Suchman 1987) defining appropriate education,
experience, and knowledge is not an easy task. For example, studies of human cognition show that when people grapple with opposing insights, they understand the different aspects of an issue and come up with effective solutions (Takeuchi et al. 2008). Employees should have the ability to approach and assess objectives and problems from a different level or perspective (Applegate 1994), all of which require a creative mindset (Faltin 2007), knowledge, and skills. Knowledge determines if a design task constitutes a problem. For without knowledge there is no reuse, and knowledge is a critical resource underlying most strategies (Visser 2006). Knowledge is also acquired through experience, by working on many projects, but action and experience do not inevitably lead to learning (Jarvis 1995), since the actions and biases of individuals are selective against negative evidence (Brehmer 1980).

The most important determinant of individual differences in programming is the knowledge base possessed by a programmer, so that a programmer can be an expert in one domain and a novice in another (Curtis 1984). From the practice-based perspective, knowledge is emergent, deeply grounded in practice, and not something that can be fully captured, codified and transferred (Whyte et al. 2008). Learning in the workplace is both a cognitive and a social activity (Gherardi et al. 1998), and the key question is how new product development teams connect the knowledge flow inside and outside of the team to accomplish their innovation goal (Büchel 2007) because the division of labor/practice creates epistemic divisions (Duguid 2006). Individual developers perform many design activities, but the design of common modules, larger systems, and components is typically a highly collaborative process which involves many stakeholders who work together in teams or ad hoc groups, to discuss or find possible solutions in meetings and unplanned work-related discussions (Dekel and Herbsleb 2007). They construct a shared vision out of collected and presented data that matches their own situated experience, i.e., they increase their own and group knowledge. Human interaction is the source of knowledge emergence (Kakihara and Sørensen 2002). However, the cost in time of all these informal and planned communications can become high (e.g., Herbsleb et al. 2001), just as a lack thereof can cause possibly avoidable rework. Furthermore, when one fails to relate one’s own actions to one’s
own results, or cannot compare them to someone else's, the personal initiative needed to make meaningful improvements cannot eventuate.

Although technologies are difficult to adopt (Lyytinen and Rose 2003), authors of previous empirical studies typically assumed that the subjects had sufficient solution domain knowledge. In our study, knowledge and learning applied equally to application and solution domains, and quality included bad design, implementation, managerial, and procedural decisions. To detect and rectify these decisions took knowledge that, on one of the two projects, either was not available, or there was no initiative, resources, time, or will to experiment and improve. For example, many people have intellectual architectures but few can translate these into actions, agreement, and creation (Grinter 1999). Learning to program is essential, but it might take up to ten years for a novice to become an expert programmer (Soloway and Spohrer 1989), and programming is so complicated that developers can work for years in a single language and still not learn all its nuances (Whittaker and Atkin 2002). If so, then one can expect that the professional who has only recently picked up a new design method or programming language cannot have sufficiently developed the knowledge and skills to perform as expected. Likewise, the project manager who manages a project that uses a new technology may not know how to adjust to the new situation. Research has shown that individual differences among project personnel (and this should be even more true in the unstudied area of programming managers) account for the largest source of variation in project performance (Curtis 1984).

3 RESEARCH APPROACH
We are familiar only with publicly available parts of the CHAOS survey (Standish Group 2009). Based on these, we conclude that there exist differences in opinions expressed by the practitioners in the survey and those by the authors cited above, which does not come as a surprise. The criteria shown in Table 1 are largely subjective, such as clear objectives and vision, proper planning, and realistic expectations. At the same time, competence, experience, and objectives do not rank as high in the survey as some researchers have suggested. The ten criteria can be interdependent, such as clear objectives and vision, focused and hardworking staff, and proper planning. Can personnel become
focused and hardworking even though their interest in the project has been partial? Our findings suggest that the answer to this question is yes, *they can*. Does a team that from the outside appears harmonious actually collaborate and share a mental model and vision? Our findings suggest that the answer to this question is *no, not necessarily*. If the computer science graduate cannot design software (Eckerdal et al. 2006), then what is the realistic performance expectation for a novice? To answer this question, the project manager can explore four scenarios: 1) a novice can only work on something simple, which is not productive, 2) a novice should be allowed more time and have a mentor, which is not cost effective, 3) a novice can become an important contributor provided a design has been selected to compensate for the lack of competence, which is preferable, and 4) a novice should be treated as any other team member, which exposes the project to risk.

The success criteria in Table 1 apply to the program, but it was not always clear whose responsibility it was and how to achieve success, because they crossed a role’s boundary. Given these, we neither wanted to start or end our study with a preconceived notion of bad and good practices, nor launch an inquiry into inferiority or superiority of a particular method or model, because every project is unique. Instead, our objective was to observe and record the ongoing flow of actions, decisions, and events, and to solicit explanations and opinions from those who were the principle actors. In particular, we investigated the importance of architecture, experience, knowledge, organization, planning, role, skills, strategy, and vision as part of the managerial influence throughout a software lifecycle. The study also sought to elaborate on the differences and similarities found in individual actors, principal organizations, and projects’ profiles, and identify the ways in which these individuals and organizations behaved, contributed, and exerted influence within the environment. Our study was conducted in a natural environment in which two very different project teams were developing two nearly identical software systems over a period of nine months. The type of occasion was highly extraordinary, and a qualitative empirical study with overt observations (see Mack et al. 2005) appeared most appropriate to provide contextually rich data and specific insights into the local perspectives of the study’s participants.
The two projects took place in two separate locations, and we could closely monitor only the project team that was located in the same city that we were. Formally, our affiliation was with that project (i.e., Project 2 or P2 for short). We learned about developments in the other project (i.e., Project 1 or P1 for short) mostly through their interdependencies. Our insight into P1 was also affected by a lack of communication and transparency between the projects. The lack of collaboration among the project teams affected our ability to collect information at its source and seek clarifications and interpretations from those directly affected or responsible. On a positive note, although Project 1 team members were not obliged to participate in our study, they were open to talk to us. In return, we limited our interviews to after hours and lunch breaks and kept them to 15–30 minutes. To compensate for this asymmetry, we asked all the actors to review our notes and summary reports. They could also remove any information they did not want to be permanently entered into our records.

The data collection was based on complete observations (Schutt 2009) and sporadic overt participant observations (Macionis and Plummer 2008) of daily routine and meetings, and analysis of secondary data, such as project documents and meeting minutes. We also used semi-structured interviews (Patton 1980), whereby individuals explained about the negatives and positives they experienced on a particular task and tried to relate them to their experience, knowledge, teaming, training, or some other relevant aspect of their project. In this sense, answers such as *I am late because he is late* were insignificant. Our visits to Project 2 were limited to once or twice a week for the first four months and coincided with only those events we wanted to attend or were invited to. In particular, we attended a team meeting once a month, two requirements elicitation sessions, nine code and design reviews, the open session of a one day interactive seminar by IONA Technologies, a meeting to negotiate the cost for an outsourced component, a demo for the customer, and a system handover session. We conducted interviews with all the individuals singled out herein, i.e., all members of the P2 team, six of the initial seven members of the P1 team, the P1 software architect, both project managers, and some personnel of the customer. After the first four months, our visits were reduced to once or twice a month.
4 EMPIRICAL STUDY ENVIRONMENT

This empirical study took place at a multinational natural resources corporation, that was ISO 9000 certified, and with strict adherence to quality procedures at all organizational levels. The workforce was stable due to the above average remuneration packages, employee stock options, and skills and technology for which there was little demand outside of the corporation, both locally and nationally. As part of their organizational learning process, employees had to prepare a detailed annual report of their work, as well as future directions and needs, for a panel of senior experts and managers to appraise and plan for information flow, staffing, training, etc. (e.g., Blackman and Lee-Kelly 2006). Seminars in core competencies were offered to permanent employees and contractors alike, and participation was encouraged.

The customer was a division that processed raw materials. The technological process had three stages, which were all similar, using chemical compounds and elements, and heat to process a batch of feedstock. Stage 1 was mandatory, and the other two were optional, depending on the characteristics of the ordered product. The stages were computerized and each was controlled by a standalone supervisory control and data acquisition (SCADA) system that was accessed via VT100 family terminals and running on a PDP family computer. Data exchange and signalization between stages was manual, i.e., via paper or phone. Operators had to type data into a computer via a keyboard, and mistakes were easy to make. Process data were stored to flat files and could be viewed in a table on a terminal or printed out for paper archiving.

The three SCADA systems had been in use for over two decades and we will refer to those as a legacy system. They were implemented in Assembler and Fortran (e.g., Metcalf et al. 2011) computer programming languages by an IT division (IT1), which was responsible for its maintenance. The five software engineers who implemented the legacy system were still with IT1. Four of them were promoted to more senior roles, and one was with P1. As the production facility and the legacy system had been upgraded over time, another IT division (IT2) and a (process) technology division (TD) were providing to the customer various IT services and control point maintenance respectively, as well as implementing additional systems, such as the computerization of the
chemical laboratory for which a standalone mainframe with a relational database (RDBMS) was installed. However, the technological process became outdated and quality of products began to lag behind market needs. Waste could not be reduced, the profit margin shrank, and the market leader position was threatened. Senior management decided on a major upgrade of the production facility, which included the replacement of the legacy system. Their goal was to build a state-of-the-art SCADA.

The new fault-tolerant and integrated SCADA systems were to run on UNIX workstations connected to a network and implemented in Object-oriented technology (e.g., Booch et al. 2007), as well as backed up by a RDBMS. Each SCADA system would have a three-tier client-server architecture, so that multiple active and passive clients could connect to it; each stage would have two UNIX workstations that would run in parallel; and each stage would have a RDBMS that could be accessed by workstations at other stages so that optimal process parameters could be selected for each batch of feedstock. Another important enhancement was the histogram for archived and live data that would replace the table and allow raw data to be displayed. New forms would be provided to input parameters so that an analysis and simulation could be performed before a technological processing started and during one.

Apart from such features enabled by the new technology, the new systems were functionally identical to the legacy system, and the current personnel at IT1, IT2, and TD had no unknowns in the application domain. In fact, their knowledge of the legacy system and technological process was intricate. In the past, as they worked on the implementation and maintenance, they regularly visited the customer for meetings and work, and got to know personally most of the personnel. The P1 team had no experience with the solution domain, because they had never before used Object-oriented technology, nor built a network enabled multitier software system with a graphical user interface. IT2 and TD were not affected by the change of technology.

The third IT division (IT3) involved in the development of the new SCADA systems was located in another city. It took about two hours to travel by car between the locations. IT3 had been working on large scale hardware and software projects for external customers, such as enterprises, and government agencies and departments. IT3 was
experiencing a prolonged period of volatility in their business, and their goal was to create new business opportunities. P2 was their first step in establishing a presence and recognition with internal clients. Since IT3 had never before worked with the customer they had no application domain knowledge, but they considered themselves experts in the solution domain. IT1 perceived IT3 as a potential rival.

The development environments for both projects were set up identically. IT1 and IT3 each purchased a UNIX workstation, and each software engineer used a Microsoft Windows personal computer to access the workstation via an interface. The customer did not participate in the purchase of neither the workstations nor the interface, and did not plan to share their new hardware with the projects. While the workstation configuration was sufficient to run a new SCADA system efficiently, the development work suffered delays and slowdowns whenever multiple engineers used the workstation at the same time to compile and execute their programs. As we report below, this became a major source of problems for the P1 team, because of the team size, and because of their inexperience with the development environment their work suffered from constant trial and error attempts.

5 TWO PROJECTS
At the time of this study, only two of the three SCADA systems were scheduled for replacement, i.e., for the first two stages of the technological process. The customer demanded that both systems should be in production within nine months or less, and the last three months should be used for the testing (Figure 1). Both projects were awarded to IT1. For the requirements elicitation, IT1 allocated two months to P1 and 1.5 months to P2. For the implementation, IT1 allocated four months to P1 and 3.5 months to P2. For the training, testing, and parallel operation with the legacy system, IT1 allocated three months, before the handover would be completed. The testing was not only concerned about the new software, but also about the new algorithms for the technological process that could not be fully tested before both systems were in production. IT1 reasoned that by reusing work products from P1 on P2, P2 would require fewer resources to implement and would keep maintenance cost down; however, the plan never eventuated. Although they were developing nearly identical systems, these two projects
represent opposite ends of the spectrum, and even this initial plan for the program would only formally tie them together.

IT1 estimated that they lacked resources to take on both projects and decided to work only on P1, which was for Stage 1. IT1 outsourced P2, which was for Stage 2, to IT3, but the IT1 estimate was not disclosed. This change of plan was of no concern to the customer, and IT1 remained formally responsible for the program. The P2 project manager was reporting weekly progress to the P1 project manager who sat for both projects in weekly progress meetings with the customer senior management. The meeting minutes were never forwarded to anyone at IT3. Instead, the P1 project manager provided feedback when the P2 project manager or IT3 senior management (i.e., the IT3 director and the P2 project sponsor in Figure 2) asked for it, and then those were his own comments and interpretations. We were assigned to work with the P2 team, and the P2 project manager was our main source of information for both projects. We do not know what exactly was discussed in the meetings with the customer. Our contacts with personnel outside the P2 team were limited. When invited, we accompanied the P2 project manager to open meetings and for visits. Even so, in our interactions with personnel we tried to remain impartial and take the same approach.

![Figure 1 The original schedule for the program](https://doi.org/10.5771/9783828868427)

**Project 1: personnel and technology**

Initially, the P1 team consisted of a project manager, a software architect, and seven software engineers (i.e., developers in Figure 2). The project manager was an engineering technologist by education. He had 10 years of managerial experience and 15 overall with the corporation (i.e., with IT2). P1 was his first project at IT1 and the first project that used the
new technology for which he lacked familiarity. In our contacts with the P1 team, we learned that he was regarded as a friendly person and successful manager during his tenure at IT2, but we do not know why he decided to join IT1. He was familiar with the customer (i.e., the management and personnel), their business, and the technological process. As a manager, he was assigned an office, but he chose a cubicle instead so that he could sit together with his team. He was first to come and last to leave the office. In his own words, his job was to manage cost and scope, and his teams took care of technology and related issues.

A software architect is responsible for the organization of the overall system that is constructed from many components (Garlan and Shaw 1994). The P1 software architect had four years of experience, and used to work for IT2 before joining the project. While at IT2, he worked on a project together with the P1 project manager, who was always full of praise for his ambitious and talented young architect. Two of the seven engineers were newly recruited computer science graduates. The average work experience among the seven was seven years (i.e., 0, 0, 6, 6, 8, 9, and 22). IT1 hired consultants to support the project but still, as time would reveal, their main risk could be found in a complete lack of familiarity with the new solution domain technology. Even the graduates were simply novices who hardly did anything outside the curriculum that taught Java (e.g., Arnold et al. 2005). P1 was preceded by a five-day training session on C++ (e.g., Stroustrup 2000), a three-day session on the Object-oriented Method and UML (UML 2010), as well as a one day tutorial on the RDBMS. Later, IT1 organized a half-day seminar on CORBA (CORBA 2010).
Project 2: personnel and technology

At the time when P2 was awarded to IT3, there was no team to work on the project. P2 was estimated to be slightly smaller than P1. IT1 gave a demonstration of the legacy Stage 2 system to the P2 project sponsor. He reasoned that P2 was a small project for which recruiting two contractors (i.e., a project leader/software engineer, and a software engineer) would suffice. The P2 project leader turned manager had seven years of work experience and Corey, the software engineer turned team leader, had five. They both signed nine-month contracts. The P2 project manager had both managerial and technical experience and often played both roles on past projects. He worked in a number of business domains, such as banking, defense, healthcare, and telecommunications, but not in this one. He found management and technology inseparable, which allowed him to effectively lead by example. He was not everybody’s person but, as this project has demonstrated, he had always tried his best to deliver according to expectations and needs of his customers, and his efforts were appreciated.

Corey spent the last two years working internationally on a software project for consumer electronics with almost the same technology used on this project. Before that, he worked as software engineer for an insurance company. This was his first job to work as a contractor since returning back home. He was excited about catching up with his family and friends, which, at times, affected his work on the project.
He got carried over easily and spent a lot of time on the phone. The P2 project manager has described Corey as a solid programmer who needed reminding about his actual job. Corey was a communicative, easy going, and fun loving person who quickly got to know everyone in the office. The workspace for the two was set up as an open plan office, with six tables aligned by the window and along a corridor partition. The layout allowed them to hear, see, and speak to each other while sitting at their desks equipped with Microsoft Windows personal computers.

Two weeks into the project, the P2 project manager felt that there would be lots of liaison and managerial work for him to do, so the P2 project sponsor recruited Mary to the team. She was a computer science graduate and this was her first fulltime job. She was a bright and outgoing, albeit headstrong person with many interests. Unlike the two P1 novices, Mary appeared knowledgeable and proficient in the technology. She took on part-time work as a student to earn money for her fees. She especially liked working with computer graphics and on graphical user interfaces. During the requirements phase, when the P2 project manager was away at the customer and IT1, Corey became the team leader. Corey and Mary got along really well, but Mary’s relationship with the P2 project manager was strenuous at times. She was willing to listen to his advice and ideas, but she liked to prove that her experience was also valuable. Unfortunately, while she was an efficient programmer, her work suffered from mistakes, which concerned the P2 project manager.

Cost and effort estimates
These were time and materials projects, with two deliverables: a new system, and a requirements, and IT1 was also responsible for the training. Initially, the IT1 senior management made cost and resource estimates for the program according to the three phases and time frame defined by the customer. IT3 was informed about the initial P2 cost estimate when approached by IT1 with a proposal to take over the project. The P2 project sponsor did not know how the P2 estimate was made, because IT1 never disclosed a project proposal to IT3. Instead, the P1 project manager only explained basic requirements and invited the P2 project sponsor to a demonstration of the legacy system for Stage 2. After that, IT3 worked on an estimate and risks, and each IT submitted a formal proposal. Based on our insight into the two projects, we concluded that
IT1 planned to allocate each use case to an engineer for the duration of the implementation phase, whereas the P2 project sponsor guessed how much effort would be needed to reuse P1 code and how many software engineers to recruit for the project. This likely explains why IT1 believed they could not take on both projects, and why there was such a difference between the estimates.

The P1 project manager presented the P2 proposal to the customer senior management, and provided feedback that the price was too high. We do not know how the negotiations between the parties proceeded, what arguments the customer used to drive the price down, and what was the P1 project manager position. We do know that the customer had some understanding as to how much money they wanted to pay for the projects, but the source of that information was not disclosed to us, i.e., whether the customer consulted a third party or used some other source of information to figure out a ballpark. The customer did not want to pay for any risks and training due to the new technology, and argued that IT1 would be able to reuse that knowledge and skills on future projects. Then, the P1 project manager and the P2 project sponsor negotiated a new proposal. The P2 project sponsor reduced the P2 cost estimate down, but later the P1 project manager commented that IT3 did not have to comply with his requests if they had believed that the cost would be higher.

The P1 project manager estimated a higher cost for P1 because it was somewhat larger than P2, and he factored in the reuse of code by P2. The P2 project sponsor argued that with or without reuse he had to hire enough personnel because reuse was not necessarily easy. The final P1 cost estimate was about 20% greater than that of P2, but the P2 hourly rates were much higher due to the different cost structuring in outsourcing situations. Even so, with only two contractors working on the project, it looked excellent. Unfortunately, the P2 project sponsor underestimated the effort because he was not familiar with the legacy system, which appeared simple to him. His estimate was based on the brief demo and high level description of the legacy system for Stage 2, because the requirements had yet to be produced. We do not know whether this was a matter of confidence or negligence, but the IT1 and IT3 senior management did not consider the risks of P1 not being able
to deliver code as planned, and the distribution and unfamiliarity of the teams.

The objectives of the IT1 senior management were to acquire the new technology and build the system, but they underestimated the effort because they could not fully apprehend the challenge. Being the custodians of the legacy and new systems, the IT1 senior management reasoned that whatever the cost of development, they would charge for it accordingly because the technology was new to them. They believed, nevertheless, that their estimate was realistic because nothing about the new system raised concern. They would hire consultants and provide training for their personnel in new technology. There was no reason to expect the customer to ask for major or even any changes at all, because they were all familiar with the technological process and upgrades of the facility that were planned for or under way.

The IT3 senior management never expected to overrun the P2 budget. Even so, they decided to treat P2 as a fixed price project and present themselves as a competent and reliable partner. Their objectives were to build a quality system, develop new relationships, and use this project as a future reference. In hindsight, the tactic of the IT3 senior management to go about their contract as if a fixed price one did not bode well with the IT1 senior management. As problems were piling up in P1, and the P1 project manager was repeatedly asking for additional funding, it became increasingly more difficult for him to justify his requests. As one would expect, the customer senior management could not understand why P2 was performing as expected and P1 was not.

**Project 2: side project and split**

P1 and P2 were supposed to share code and design, with P1 being the supplier of common features. P1 started first and P2 was scheduled to start a month later (Figure 3). The P1 project manager estimated it would take six weeks to get their requirements ready for review and signing off by the customer, which would take an additional two weeks. At the same time, a leading technology consulting firm (TCF in Figure 2 and Figure 3) was developing a software infrastructure with common components, such as the logging subsystem and event handler, for the new SCADA. A technical leader and two software engineers worked on the project. The same consulting firm was hired to provide training
in Object-oriented technology. Twelve weeks into P1, the IT1 director terminated the TCF contract with immediate effect, and they never completed the infrastructure project that was taken over by an IT2 team. The IT1 director believed that the TCF was deliberately delaying the completion date and overcharging. Only one consultant was rehired to coach the P1 team. Later, the technical leader commented that they needed only one more day to complete the software infrastructure project, to which his audience gave a shrug of disbelief. IT3 never used their consulting services, relying instead on their own expertise.

The reuse strategy would make P2 very much driven by P1. After the P1 requirements got signed off, P1 entered the implementation phase, and both project managers started negotiating a P2 plan for the implementation phase. It soon became obvious that P1 was not progressing according to plan. Because of the difficulties, the P1 project manager asked for patience before they could sort out their problems. He neither explained what the problems were, nor presented his schedule. The P2 project manager asked his team to first look at the completed modules of the infrastructure, analyze requirements for both systems, and identify the differences and similarities in order to prepare themselves for the reuse. The P2 team also worked on a conceptual design for a new Stage 2 system because the P1 team might not be up to the task.
P1 entered the implementation phase half a month ahead of P2, but the P1 team did not have anything ready for the P2 team to look into or reuse, and they would not commit to a date or schedule. Instead, a week later, the IT1 director asked the P2 project sponsor whether IT3 could pick up a side project (SP in Figure 3) for the same customer. This was a data acquisition and display program that would run on a dedicated Microsoft Windows personal computer and was connected to a thermal probe via special hardware. This project was sponsored by TD, because they were responsible for the device (see Figure 2). IT1 had planned to work on it, but then decided that they could not do it. The P2 project manager was happy to pick up the project and keep Mary busy for two weeks. Her job was to develop a graphical user interface. She was joined by a software engineer (i.e., +1 developer in Figure 3) from another IT3 unit who worked on a software interface to the hardware. The P2 project manager (P2 PM) designed a solution, helped the developer in understanding the algorithm written in Fortran, and he managed the project. The side project also helped control the P2 cost because Mary and the P2 project manager could charge their work hours to it.

During that period, the P2 project sponsor recruited two more software engineers (i.e., 2 new developers in Figure 3) to join the P2 team because requirements revealed that the new system was much
more complex than anticipated and lots of data needed to be stored into the database. The two engineers included a database specialist and a developer with some low-level networking experience but no CORBA. The engineers joined Corey in his work on the analysis and conceptual design. The P2 project manager explained to his team his vision of the project in which members were committed to do the best they could to achieve project goals despite obstacles and time pressure. He concluded with the following remark *I see us outperforming the P1 team and crossing the finish line first!, and the lack of progress by the P1 team supported that. The open-ended delays began to annoy the P2 project sponsor, because P2 had made no tangible progress since completing the requirements phase. While the side project eased budgetary concerns, the switch also meant that the P2 project manager and team eased their focus on the main task. The P2 project sponsor repeatedly asked the P2 project manager to accelerate work and finalize his project plan, but his answer was always *The P1 project manager wants us to wait until their issues get resolved!*

Nevertheless, the P2 project manager started preparing his team to proceed on its own. Upon finalizing the architecture for the P2 system the P2 project manager summarized the main ideas to his team and together they discussed individual work preferences and project needs. The P2 project manager cautioned his team that *efficiency was more important than effectiveness on this project.* His goals were to build a *simple, responsive, fully functional, dependable, and consistent system, within the shortest time possible,* since the project was already late and *more uncertainty was possible due to the time pressure and developments on P1.* To ensure his team complied, he *might challenge their detail designs and estimates.* He and Corey assisted the new members in catching up so that they could all start working together on the object design. The P2 project manager also devoted time to help an engineer with CORBA.

The P2 project manager could not further delay the project. In his opinion, the P1 team would not be able to deliver on their promises any time soon. His understanding was that the P1 plan was flat, and that all use cases would be implemented at the same time, instead of being prioritized. It was also unclear whether the prioritization of work within a use case was sufficient to enable reuse. The fact that the P1 team increased its personnel count to thirteen went towards supporting
his opinion. Given the amount of problems that the P1 team had experienced so far, it could be expected that their code and design would have many errors, and the P2 team did not have enough personnel to deal with it. The communication and interaction patterns between the teams suggested that it would be very difficult to complete the program with any firm deadline in mind. Almost three months into P2, senior management decided that each project team should proceed on its own. The only similarity in the implementation between the two systems was the 3-tier architecture and the software infrastructure with components, because nothing else had been discussed neither before nor after the P2 implementation phase started.

Later, the P2 project manager commented that the delay was positive in the sense that the P2 team managed to prepare well for the implementation phase. The object design was detailed enough and good enough to allow a realistic and solid project plan to be constructed with very few unknowns. The daily routine was well planned for. Everyone on the P2 team was clear about the challenge. The P2 project manager added that nobody on P1 gave much thought about the object design when estimating the cost and timeframe. In his opinion, the P1 project manager was only concerned about and planned for the implementation, but he never explained what exactly the term implied. The P2 project sponsor never raised that question in negotiations either, and he never discussed with the IT1 senior management any details about the intended coordination, interaction, and sharing between the teams.

6 REQUIREMENTS ELICITATION

Due to customer's demands, both projects were planned according to the waterfall model (e.g., Benington 1983). No project would proceed before requirements were signed off, and the system acceptance criteria was fully defined and committed to by both parties. No deployment would take place before the new system was fully implemented, because it would be neither practical nor useful for the customer to work with an increment. To install a new system, they had to shut the facility down, and that would take place during the next regular annual maintenance period during which they would be able to upgrade the facility. While there was some flexibility in the timing, because orders had suddenly picked up, it was important that project schedules fit within the original
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timeframe. Both projects were staffed and started as initially anticipated, but soon the management of the projects and their performance started to diverge, as the requirements phase has first revealed. Innovation is powered by a thorough understanding, through direct observation and use of targeted prototypes, of what people need and want in their lives and what they like or dislike about the way particular products are made (Brown 2008).

**Project 1: requirements elicitation**
The Stage 1 technological process was never standardized, and operators used various sources of data and manuals, as well as their experience and preference when processing an order. The legacy system for Stage 1 was never fully documented, and many changes to the code were made upon informal requests. All these had to be analyzed and either reconciled with the new algorithms and workflow or removed. The P1 project manager appointed Shane to lead the task and work with the customer. Shane was a graduate engineering technologist who joined IT1 eight years ago. His job had been to maintain the SCADA for Stage 1 and his good work was long recognized. Another software engineer was helping Shane. He was among the five who had developed the legacy system for Stage 1. The customer appointed their technology manager and two operators to the team. The requirements team had to produce a comprehensive requirements document and standardize the technological process. Although a demanding task, it was completed on time, but unresolved issues with the new graphical user interface for UNIX workstations remained.

Both parties were familiar with the legacy user interface and they both assumed that the contents and layouts of new forms would resemble the old forms, which served as their reference. The legacy system offered little design flexibility, whereas the new software offered seemingly endless opportunities for improvement over the old ergonomics. In their meetings, they simply used pen and paper and a whiteboard to discuss new ideas and create a hardcopy for future reference, but the process was tedious. The operators could not find a common ground when discussing details, such as the appearance, exact layout, visibility, and how to enable different functions. In fact, as we have learned firsthand during P2 requirements elicitation meetings, some operators
were not excited about the new system. Because the P1 team members had no experience with the new graphical user interface technology, they did not consider building a prototype, and the P1 project manager said that *no such provision was in the project budget and plan*. Instead, after consulting with the customer senior management, the meetings were abandoned due to *lack of progress*. It was decided that the Stage 1 operators would approve the new graphical user interface during the handover.

The P1 project manager neither engaged on the requirements nor tried to resolve the problem with the new forms. He and Shane both found that a minor outstanding issue. The P1 team believed that they thoroughly understood the mental models of the operators, and that they knew how to integrate the new system into the workflow. Furthermore, the customer told the P1 project manager that new monitors would all have the same screen resolution and size, and he developed a conviction that no monitor-specific adjustments of the graphical user interface forms would be necessary. Since the P1 project manager was not a software person, neither he nor his team considered or discussed building a version that could dynamically scale to a monitor. Instead, he relied on common sense and his perception of simplicity that would guarantee him a timely project completion, which assumed *no scalability of forms*. Generally, the P1 project manager adopted the strategy of first refusing to consider any changes to the requirements after the signoff. But when he decided to discuss a change request, he asked for additional funding by portraying it as a major change, and he instructed his team to do the same. However, as time would tell, the operators flatly rejected the new Stage 1 system because of its graphical user interface and overall poor quality.

**Project 2: requirements elicitation**

The P2 requirements phase was much more difficult. They had only five weeks allocated, but no application domain knowledge. The P2 project manager picked up the task, but he neither knew how to locate the customer nor who to talk to. He asked the P1 project manager for help and an IT1 engineer who was about to leave IT1 was assigned to the task, but he was not keen to work. After two days with lots of talk and little work done, the P2 project manager complained about the situation to
the P1 project manager who then appointed Robert to work fulltime on the task. Robert was a software engineer with nine years of experience, with seven of those at IT1. His main job was the maintenance of the legacy system for Stage 2. Robert and Shane were good colleagues, and they were both members of the P1 team. Robert was aware of Shane’s work on requirements and the difficulties that he had experienced. Like Shane, Robert was proud of his knowledge. Robert was also a good listener, open to ideas of others, and was a patient teacher to the P2 project manager regarding the application domain. He wanted to assist in building the best possible new Stage 2 system and was excited about the opportunity, as was the P2 project manager who found the whole situation challenging and new. The customer appointed the technology manager and a junior Stage 2 operator to the requirements team.

The first two meetings with the customer were difficult for the P2 project manager because he did not understand the terminology, and thus he could not engage in the discussion. Fortunately, Robert immediately took over by preparing action points for each meeting, and discussing issues. After each meeting, the P2 project manager spent time with Robert analyzing the minutes and asking about unfamiliar terms and words, and other specifics. Nevertheless, the P2 project manager realized that the main source of difficulty was the graphical user interface. No one could explain how many components could be fit into each form, what components should be used, and how to improve the current layouts, or perhaps completely redesign some of the forms. Since the new system would also serve as a knowledge management system, it was not clear how to automate the workflow and present information, and the P2 project manager certainly did not understand what the operators needed the knowledge for and how it had been archived, and used in the technological process.

The process of designing the new graphical user interface was tedious, since during each meeting there were different operators sitting in along with the division director and the technology manager. The production was organized in three shifts, and senior management wanted all the operators to have their say in order to avoid dissatisfaction with the new system and possible workers union action. It comes as no surprise that at each meeting a new set of drawings was produced on the whiteboard that had little in common with those before, and that no progress was made.
To further complicate the matter, there was a sharp division among the operators, with management unwilling to take sides or mitigate the conflict. The older operators resented the idea of having a new system. They claimed that the legacy system could be improved instead, as per their proposal. They disliked the histogram and wanted to keep the table instead. In contrast, the younger operators were enthusiastic about the prospect and wanted to use all the different components they grew accustomed to when using applications for Microsoft Windows. The constant stream of diverse ideas and the dichotomy of positions created a fragmented environment for the P2 requirements team, and the P2 project manager concluded that without a prototype of the new graphical user interface displayed in a monitor, it would be impossible to complete this important task with certainty and confidence.

The P2 project manager decided to build the prototype in Visual Basic (e.g., Lim 2012) and install it on a personal computer so that the operators could obtain a better idea about the new graphical user interface while playing with it. The prototype could only switch from one form to another, pop up dialog boxes and menus, or provide some visual feedback, such as the changing of colors, and the displaying of text messages, so as to acknowledge an operator’s action. It took Mary and the P2 project manager a couple of hours to build it according to the old forms layout and whiteboard drawings. The P2 project manager never charged the customer for it because Mary was sitting idle anyway. While this was not exactly the same look and feel of the things to come, it proved close enough, and the prototype attracted much attention. Now, everyone interested could develop a realistic idea of and gain some experience with the things to come, and provide much more solid feedback on the color schema, components, font size, and layout. The older operators stopped perceiving the new system as a threat, and the young operators could see how their Microsoft Windows experience would be recreated in the new system. The two subsequent meetings became very productive. The prototype was redesigned to account for the new ideas, and the new user interface was designed, ostensibly to everyone’s satisfaction.

The completed P2 requirements contained 78 pages. Six use cases were inherited from the legacy system, and updated, and two new use cases were added. The P1 requirements were reused for consistency, and...
to speed up the writing. P1 had one more use case defined and 17 more pages. However, according to Robert, the P2 requirements needed more work because all external control points and devices had to be accounted for and (re)programmed to comply with the new hardware. The task took two weeks to complete, during which a cross-functional team of 18 was assembled and worked diligently to complete the work as soon as possible. The delay did not affect the requirements review and signoff process, which took one week. Overall, all parties were satisfied with the performance during the requirements phase and the achieved outcome. As the record would show, the requirements remained stable, and the P2 team needed only additional explanations on the terminology during subsequent phases because they lacked the necessary application domain knowledge. By contrast, the P1 project manager never considered taking the same approach to finalize the P1 graphical user interface. Instead, he said that his team was not just assembled two days ago but has had years of experience working for the customer.

7 SYSTEMS IMPLEMENTATION
Both project teams in this empirical study had, arguably, mostly experienced members. The requirements for both systems were nearly identical, and realized within the same three-tiered, client-server architecture, but this is where the similarity between the two projects and systems ended. Both project teams had strengths and weaknesses, but their strengths did not necessarily facilitate their performance, and their weaknesses did not necessarily threaten their project. The behavior of a system does not depend on what each part is doing, but on how each part is interacting with the rest (Senge 1990). This applies equally to artificial and natural systems. The P2 project manager commented: The process of developing a system begins with a notion of what that system is, i.e., its main components and how to best realize and utilize them. It can be driven by many factors and require making tradeoffs. The [lifecycle] model doesn’t matter, but what one makes of it. The engineer, and more generally the designer, is concerned with how things ought to be in order to attain goals and to function (Simon 1996), and [software project] managers should be decision makers and designers (e.g., Martin 2009), and even possess the competency of an engineer.
Project 1: implementation phase

The P1 project manager engaged in cost and scope management and relied on the advice and opinion of his software architect and team in technology-related issues. They all grew accustomed to taking a functional viewpoint, and only used the requirements to create a project plan. They viewed a use case as one part of the system that was developed end-to-end by an engineer who decided on the tasks, sequence, and made estimates. This strategy worked well on past projects managed by the P1 project manager when systems were closed and integral, and required only basic programming skills. This project was different, but the P1 team was not overly concerned about the new architecture and technology and how could these affect their work. The P1 project manager repeatedly stated that IT1 prepared well for the project by hiring consultants and providing ample training to the personnel. Also, five of seven team members had previously worked together and were all good colleagues among themselves.

Initially, each engineer was assigned one use case to implement. The software architect picked up one outstanding use case, and the other one was delayed until a resource could become available or recruited. The plan for reuse by P2 prompted the P1 team to first work on the server, followed by the graphical user interfaces (i.e., the client), and the RDBMS part. The technology was new, and no one could make estimates with confidence. For example, three to four weeks were allocated to implement a (graphical user interface) form. When these ideas were presented to the P2 project manager, he commented that his team was much smaller and would not be able to complete the project on time or with any certainty. His team would be underutilized and without control… [and] would have to understand the work products, map them to Stage 2 requirements, and then modify or reuse them… [but] they could not reuse code fragments. How would teams communicate? He asked for shorter time intervals in which work products would become available in coherent and small batches, but the talks ceased because P1 was experiencing difficulties.

Those work assignments put each P1 engineer in a position to individually face constant and new challenges, which led to internal fragmentation and a loosely coupled team. Each engineer had to learn how to create and use CORBA interfaces, interact with the relational
database and map their classes to the relational model, program graphical user interfaces, and use the infrastructure. In the process, they all had to become solid object-oriented designers and C++ programmers to implement complex algorithms. The software architect was also new to the technology; but, in order to alleviate the learning needs and help the team, he made himself available to his colleagues and spent time contacting customer support and the software technology experts (see Figure 2) on their behalf. The engineer with six years of experience who had been assisting him in system related issues became the principal for the graphical user interface design, and he tried to help make forms look consistent.

The lack of consistency had two root causes (i.e., the lack of systems thinking, and the work assignments) facilitated by the isomorphic team structure. The team failed to develop a shared conceptual model of the system and did not have the will to enforce consistency due to the patchy and slow progress. The lack of knowledge and skills prevented the team from considering how to use technology to their advantage, instead of settling for the most obvious designs. They explained that *the pressure to produce made them think only about the schedule*. They neither had a common approach to testing nor a consistent quality procedure. When a problem surfaced, they made *ad hoc* decisions, and rework was not an option. For example, some algorithms were implemented in the server, some in the client, and some were split between the two. As a result, the interface between the client and the server depended on where the use case was implemented. They never gave a demo to the customer or solicited comments, because the P1 system emerged only after all use cases were implemented.

The work assignment strategy created additional efficiency and quality issues, and multiplied risks because the lack of the shared mental model and the loose work couplings prevented the team from exploring opportunities towards efficiency, and it impaired effectiveness and teamwork. For example, each engineer took three mandatory tasks to implement the forms of a use case, which were: 1) implement forms, 2) implement a CORBA interface for the client and the server, and 3) integrate the forms and the interface. The testing either added one more task to write test code that was later discarded, or had to wait for server code and database integration. The need to acquire knowledge and
develop skills for the tasks led to poor quality and unreliable estimates because they simply did not know enough. Even more time was wasted because the tasks were exploratory instead of becoming repetitive. For example, most of them spent time on a workaround for the same problem in the infrastructure.

However, the P1 project manager reasoned that more software engineers would be needed and the team size increased to 13. The outstanding use case was picked up by a new engineer, and on some of the other use cases now two engineers worked. An engineer was allocated to work on the issue that prevented a table from receiving keyboard events. The new database analyst created queries and tables for the team, but his main job was to work on lots of process data that had to be stored, and although he was not new to the RDBMS, his training session lasted a week. The P1 software architecture emerged only after the system was integrated (i.e., before the handover). As a result, its technical value for the project immediately diminished, and its managerial value never eventuated. The same is true for the P1 client that had to be reimplemented because the forms were not scalable (see Section 9/Project 1). Unfortunately, after the projects went separate ways, our direct contacts with the P1 team became rare and the P2 project manager could only provide scant information.

**Project 2: implementation phase**

Three months into P2, senior management decided that P2 should not wait any longer for P1 to make progress, and no reuse of code and design took place except for one algorithm that was completely revised after requirements got signed off. The P2 project manager also served as the P2 software architect. P2 was also a waterfall project, but for this phase he opted for an architecture first and incremental strategy so that problems and tasks would become repetitive instead of remaining exploratory, and project complexity and risk would diminish over time by reusing components and designs. The increments took one week to complete, which was enough to implement a use case, or a testable part of it. The small milestones were desirable because the implementation phase was short and one third of it was already behind them. The P2 project manager assigned tasks as per expressed interests and project needs. Mary was responsible for the client (i.e., the graphical user
interface) and Corey for the object design and server. The other two engineers worked on outstanding server tasks, and either on CORBA or RDBMS.

The task assignments followed specializations to the extent possible, which facilitated efficiency and quality, but Mary was underutilized. It took Mary a day or two to implement the forms of a use case, while the server code took three or more days. The team reasoned that it would be hard for Mary to work on small pieces of code and design just to improve her timesheet, and they would have to brief and help her. Mary started an increment, while the server engineers were finalizing detailed designs or finishing outstanding work. Mary made many small changes while visually optimizing a form and frequently recompiled code, which ran fast because she was the only user of the UNIX workstation. When she finished her task, she worked on code and design reviews for compliance with coding standards and requirements, documentation, and on testing. As a rule, the engineer with free time ran tests and worked on issues. The mutual involvement in these activities facilitated the creation of a shared mental model and familiarity with the system, but it required a coherent, flexible, and simple design, which characterized the software architecture. In turn, the architecture facilitated the incremental strategy and sped up the work.

The P2 project manager decided to first build a communication interface in CORBA and a test-bed. This way, the client, the server, and the shadow process were integrated into a system before the implementation of use cases started, and the test-bed was yet another subsystem that reused the CORBA interface. The interface was flexible because multiple forms and subsystems could be concurrently served. The design remained coherent since no use case required its revision, and it was simple because the P2 system had only one CORBA interface with a receive and a send method, a message dispatcher based on numeric IDs, and the protocol used ASCII messages (i.e., text). For example, the server either sent a message to change the state of a graphical user interface component, or received a message to perform an action. The test-bed could display received messages for validation and send messages for execution. Multiple messages could be concatenated and sent as one without additional CORBA programming. By contrast, the P1 system had a different CORBA interface for each form, and each
method in an interface served only one graphical component in a form. One can argue that the P1 design was more by the book, but it was also inconsistently applied and inefficient both for the system and the team.

From a technical viewpoint, the P2 design improved the system performance (i.e., it was fast and responsive). For example, a complete form could be updated by a concatenated message. Messages were easy to parse because of the 3 digit ID + value syntax. The processing of a message was fast because its ID was the index into an array of registered components to find the receiver of the message. The data conversion for calculations and the data formatting for displaying were done at one time and in one place (i.e., in the server where the algorithm was implemented), whereas the P1 interface always sent raw data across. These decisions also simplified the P2 object design and further decoupled the client. From a managerial viewpoint, the P2 architecture also eliminated the risk due to the team’s inexperience with CORBA, and it reduced the risk of rework by simplifying the design. The weak subsystems coupling in P2 led to decoupled tasks, which facilitated scheduling. They could overlap coding, design, reviews, and testing, and reduce the time for mutual adjustments and waiting.

The P2 strategy facilitated efficiency and quality because it reduced the number of tasks from an increment’s start to a testable (sub)system. For the P2 client, it took one pooled task per increment to implement the forms of a use case. The task took one or two days to complete. Newly implemented forms were immediately tested by the test-bed, which did not require coding. Forms were dynamically scalable and they could be displayed on any monitor, so they built a client for Microsoft Windows and ran it on a personal computer, which eased the load on the UNIX workstation. Server tasks were scheduled such that it could be tested end-to-end. When implementing a use case in the server, the P2 team started with a component next to a boundary (i.e., a communication interface), and sequentially worked towards another boundary. This scheduling strategy minimized the occurrences of cases in which a task had to send feedback or request for change to a (distant) earlier task. This testing strategy could quickly detect new inherent and plausible errors and reduce the testing complexity and time.

There was always a version of the P2 system that could be immediately tested and fixed as new components were added to the
system. The P2 project manager implemented a test-bed to which Mary added a graphical user interface with various components for enabling automatic and manual testing, and for data input and output. The test-bed could also emulate the external control points and devices at Stage 2 for the purpose of testing. The test-bed was an integral part of the project because it formalized and standardized the process, and also relieved the P2 team from writing test code and the UNIX workstation from recompile cycles. It was used for black-box testing of a working version of the system and subsystems, and for checking the project status. Other decisions toward simplifying the project control, scheduling, and testing were: to implement one use case at a time and minimize work-in-process; to use small increments to create and maintain a sense of steady progress and urgency within the team that operated on a tight schedule; and to use tasks short in duration (most often only a day or two) and just enough to implement a class or a complex method or review past work. Requests for change were implemented and tested without a delay. All these created a spirit of support and a sense of mission within the team.

The flexibility and simplicity of the P2 software architecture also compensated for another weakness that was noticed on the side project (SP in Figure 3). Mary was an efficient programmer, but her code suffered from many errors, including memory leaks and performance issues. The P2 project manager used this as a motivation for the implementing the graphical user interface as a thin client. Each component and form had an ID and registered itself with a message dispatcher. Each component and form had an interface that the dispatcher used to deliver messages as events. Because the server only sent formatted data, the client could directly display them. All these made Mary’s programming work almost mechanical. Another subtle but equally compelling reason for Mary’s task assignments was that the P2 project manager wanted to teach her to appreciate discipline over impulse in her work.

Four weeks after the two projects split up, P2 had a system with two implemented use cases. The P2 project manager invited customer and IT1 management and Robert to attend a demonstration at IT3. He also wanted to demonstrate that the side project was completed. The customer did not expect this invitation, but they appreciated the opportunity to finally see concrete evidence that either project made progress. Overall, they provided positive feedback to the P2 team, which
made the IT3 senior management more confident that their plan to venture into in-house projects was finally on the right track. This was the first opportunity for the customer to see the real graphical user interface. They asked for a more vivid color scheme because their control rooms were dim and dusty. They asked for larger fonts and flash lights so that the operators could read and see them when away from a monitor. They liked the dynamically scalable forms, but they could not see its practical value because their monitors will all have the same resolution and size. The P2 project manager explained that that was how good graphical user interfaces should be built.

8 PERSONNEL AND STRUCTURE
Both projects investigated in this empirical study were undertaken for the same in-house customer, but they stand at the opposite ends of the spectrum. The P2 project manager was reporting to the P1 project manager and the P2 project sponsor on a weekly basis. The P1 project manager was reporting progress for both projects to the customer, and P2 had no formal links with the customer. The P1 personnel were familiar before the projects started, and IT1 would become the custodian of the new systems. IT1 invested in the training, and brought in consultants to work on the underlying infrastructure, to set up a development environment for the P1 team and facilitate the overall development effort. P1 can be described as a project in which both the customer and the development team had almost equal application domain knowledge, as well as complete solution domain knowledge as far as the legacy system was concerned in their respective areas of competency and responsibility.

IT3 perceived P2 as a filler project, albeit with a future potential. IT3 was located in another city and had no prior affiliation with the customer. The P2 team was formed only for the project. All the personnel were recruited by only addressing the solution domain knowledge and skills, and ignoring the application domain because that expertise was unavailable among their personnel and in the job market. IT3 had neither contacts nor familiarity with the P1 team before the project started. The P2 team members disliked the idea of visiting the customer, because the site had a dusty, hazardous, and hot environment. They complained that even the water in the water fountain was brown and undrinkable. They
saw no career value in acquiring the application domain knowledge, and they gave the P2 project manager no alternative but to become the liaison and provide the answers through his contacts.

The P2 team believed that their solution domain knowledge was by far superior, and they never felt a need to communicate with the P1 team. Their attitude was best portrayed by Mary asking *What is there to discuss with them?*—to which everyone burst into laughter. The P2 project manager tried to overcome the communication problem by introducing his team to the P1 team. He invited his team members a couple of times to join him on his regular weekly trips to the customer and IT1 during the requirements phase. He repeatedly encouraged his team to talk to their peers at IT1 and learn more about their work and the P1 system because they would have to reuse their code and design. He asked them to offer help to the P1 team so that contacts would continue. Unfortunately, these attempts did not produce a lasting result. Only Corey completed his one assignment that was essential for the P2 team. Corey set up user accounts for the P2 team at IT1 so that they could access their local information and knowledge sharing system.

Because of this negative attitude towards the application domain and the P1 team, the P2 project manager became concerned. To further complicate matters, during the requirements phase, the P2 project manager was working at IT1 and visiting the customer, and the P2 project sponsor took care of the P2 team. This gave the P2 project manager time to catch up with P1, but the P2 project sponsor negotiated cost with the IT1 senior management and recruited personnel. The P2 project manager regularly informed the P2 project sponsor about his work, but the P2 project sponsor did not reciprocate. For example, when Mary joined the team, the P2 project sponsor made Corey the team leader, and enrolled him in a two day seminar in project management that was offered by the corporation as part of their organizational learning program. However, the P2 project sponsor neither consulted nor informed the P2 project manager about the change. All these sent the wrong message to Corey who now saw himself in charge of the project. When the P2 project manager asked Corey to work on the analysis of P1 requirements, he immediately passed it on to Mary who quickly decided that *she did not understand any of the requirements.*
This situation further escalated when Mary asked the P2 project sponsor for a three-day leave. Mary was a gifted violinist and she wanted to join an orchestra for a performance. The P2 project sponsor approved her request, but he did not inform the P2 project manager about his decision. At the same time, the P2 project manager decided to build a prototype of the graphical user interface. He informed his customer about it and asked them to schedule a meeting in two days. When he returned back to IT3, he was surprised to learn that Mary had left a day earlier, and that his initiative would have to wait until the next week. That was not the kind of message he wanted to send to the customer. The P2 project manager got very upset and demanded that the team could not operate in this manner. However, Corey was not prepared to give up the power he had assumed to have. To calm the situation down, Corey remained the team leader, but was not allowed to change the project plan or task assignments without approval by the P2 project manager.

To the best of our knowledge, the IT1 senior management and P1 team never experienced such problems. The IT1 director and the P1 project manager worked harmoniously together, and so did the P1 team.

A visit to IT1 took the P2 project manager a whole day, requiring a very early start and late finish to the day, but IT3 would not pay for overtime work. Instead, the P2 project manager was offered a car to make commuting more convenient. The one way trip between the sites took about two hours by car, or three hours by intercity train and local bus. However, the P2 project manager travelled by train because he did not have a driver’s license. The P2 manager preferred to arrive 30 minutes early to prepare himself for the meeting, most often by talking to Robert. If a member of his team accompanied him, he would use that time to introduce the companion to the P1 team. The P2 project manager used the car only when a member of his team or the P2 project sponsor accompanied him, or when he invited us, but he took a nightly train back and let the driver companion return early by car. He made his visits to the customer accompanied by Robert, because Robert had a special permit to enter the site.

The P2 project manager took on the requirements elicitation so that he could get to know all the personnel involved in the project. The lack of interest by his team for interaction across a team boundary forced the P2 project manager to engage in all project issues. On the other hand, the
cost in money and time was too high to have P2 team members regularly attend meetings at IT1. On the positive side, all these factors contributed to the P2 project manager having complete control over his project and, in return, made his team happy to follow his vision. In contrast to these, the P1 project manager focused only on managerial issues, giving his team complete autonomy in technical issues. He was an engineering technologist by education, but his engineering days were long behind him, i.e., ever since he became project manager. He had no experience with or knowledge on the new technology used on P1. Neither could he engage with his team in resolving technical issues, nor understand the impact. The P1 project manager first asked his architect for his advice and opinion, and then the team discussed the issues during weekly team meetings. He only discussed issues in person with an engineer when suspecting that he was not putting in his best effort. Unfortunately, we were never invited to attend a P1 team meeting or offered access to the minutes.

To IT1, P1 was not simply a project, as P2 was to IT3. IT1 formed or utilized other teams to assist the P1 team with the technology adoption and other work (see Figure 2). Some of this work was paid for by P1 and P2, and some by IT1. The team of two software technology experts was responsible for high level issues that concerned the three new systems that would replace the legacy system, and they worked with the TCF team. Both teams were funded by IT1 and they never engaged with the P2 team. Only the experts gave a presentation to the P2 team and informed them of their role and work. The technological process team analyzed data and worked with the customer on new algorithms and methods for the processing of raw materials. That team was funded by the customer and IT1, but both P1 and P2 had to pay for their requirements review during the signoff. There were two more teams, one with IT1 (i.e., Team A) and one with IT2 (i.e., Team B) that were responsible for the implementation of the outsourced components for both P1 and P2. The P2 team was never involved in the decision-making process. Instead, when Robert learned about a decision, he informed the P2 project manager about it, because he was the liaison.

P2 used only two staff for all the interaction, i.e., the P2 project manager and Robert, whereas the P1 project manager appointed different team members to act as liaisons to each of these teams. For example,
his software architect liaised with the two technology experts, Shane liaised with the customer, and the engineer with 22 years of experience liaised with the technological process team because he worked on the legacy system implementation. After Robert rejoined the P1 team, he remained affiliated with P2 as the liaison. Although the P1 team was struggling with technology, they never felt compelled to consult with the P2 team. To them, P2 was *a different project*. The P1 project manager never encouraged his team to contact the P2 team or ask for help even after it became clear that his project was lagging behind during the implementation phase. Since the P2 project manager always sent his weekly progress reports on time, the P1 project manager did not have additional needs for information about P2. The communication between the two project managers remained formal, and the P1 project manager used Robert as the messenger. It is important to mention, however, that the P1 project manager appreciated the efforts and resolve of the P2 project manager and conveyed his positive impression to the IT3 senior management.

The difference in the modes in which the two project managers and teams operated can be found in this episode. While Team B charged a flat fee for their service, Team A worked out the cost on a request by request basis. To request their services, the P1 software architect wrote a specification to which Team A offered a quotation that was never challenged. The P2 project manager and Robert did the same thing, but the P2 project manager challenged the quotation by claiming that it was *too high*. He said that the *programming work was simple and could be completed in half the time*. The Team A leader started explaining the quotation. The P2 project manager followed up by estimating the duration of each mentioned task. To that, the Team A leader responded with *Why are you so concerned about this price? It's not that much money!* Robert was surprised with this verbal exchange, but then added that *maybe the price was too high*. Eventually, the leader agreed to lower the estimate from 16 to 10 man days. The P2 project manager concluded by saying *I’m in a difficult position myself!* Much later he confessed that *perhaps it was not a saving worth arguing about*.

There were other differences in the manner in which each project team operated. The project plan put together by the P2 team that used one week cycle to build an increment helped in developing a strong
bond. They found their work dynamic and interesting because there was always a version of the system to play with, and in the P2 office laughter could often be heard. By contrast, work by the P1 team remained individualistic, and the P1 office was quiet during our visits, with each engineer sitting silently at his desk. This difference was also influenced by the sitting arrangements. The office space for the P2 team was somewhat isolated, whereas the IT1 office could sit 80 people. The P1 team shared some understanding of their work, but their system and object design knowledge was, for the most part, developed individually by an engineer, and their knowledge of the whole system was sketchy. Most of them were not very familiar with the work of their teammates. Their knowledge and skills remained basic because their tasks were not repetitive so that they could reuse them, consider alternatives, and employ creativity with more confidence. They all contended that their work was challenging and progress was slow. Because of the work allocation and different teams involved, the decision process remained volatile, and the team structure never became recognizable.

9 IN THEIR OWN WORDS

Both senior management teams underestimated the effort, and both projects experienced difficulties, but the ways they approached the difficulties and sought resolutions were different. However, the teams were not the only party responsible for these difficulties. The customer also contributed to the slow progress with their decision to purchase the six UNIX workstations only after the systems were ready for the handover (i.e., parallel testing). Each IT purchased only one UNIX workstation because they could not justify the expense of purchasing more. IT1 estimated that they would need only one workstation to maintain the new systems, and IT3 did not have a future project in their plan at that time that would utilize the workstation. The issue of insufficient hardware resources affected the P1 team in particular because of its size. They explained to us that they tried to come up with a schedule for using the workstation, but the team was simply too big and inexperienced for a compromise solution. So they had to accept the code-compile-execute cycle to take one hour or longer. The P2 team balanced the usage of their workstation by scheduling client and server tasks in their project plan to different days.
Project 1: their own words

The P1 team never staged a demonstration for the customer or the P2 team during their implementation phase. They never resolved the issue of the new graphical user interface design until the handover process started. Neither party asked for additional meetings to finalize the new graphical user interface, nor the customer ever asked for a demonstration. The P1 project manager was confident that the new graphical user interface would not be different from the old one in its behavior, content, and layout, and the new forms would be similar. He reasoned that a demonstration would encourage operators to argue this and that, and ask for meaningless changes that would make the situation on his project more difficult. He added that after all, they wanted to keep the old system in. Another reason was that the system emerged only before the handover phase and a partial integration was never attempted. When asked about the possibility to partially integrate some of the use cases sooner rather than later, he replied that that was not in the plans. When they finally staged a demonstration of their system during the first attempt at handover, the customer flatly rejected the graphical user interface. The raw list of change requests had over 100 items. Overall, the system was unstable and required more coding and testing before it could be installed.

During the implementation phase, we interviewed the initial seven engineers in the P1 team and the software architect. When the phase started, their first task was to analyze the requirements and work on the design. They experienced many difficulties, most of which were technology related. Because the Object-oriented method was new to them, they lacked the confidence and experience to be able to change their routine in approaching and solving problems: It was easy to recognize the objects and identify their attributes, because we know about the application domain, but it is difficult to think about the behavior and how to implement it.—In the past, we simply started by writing our Fortran code because all we had to do was to add some code to the program or modify code that was already there. If a bigger change was required, we simply imitated a similar design in order to keep the program consistent. This time, we have to do everything from scratch.—We have too many new things to learn about, almost all at once. I didn't know where to start from, let alone how to combine everything together and imagine
a solution. — First I had to learn UML, and then figure out how to design and document, and then how to write programs based on my designs. I am not a beginner, but my past work was much more direct. I knew what I had to do, so I just did it. — I never worked on a multitier system before, let alone a fault-tolerant one. I am not sure if we got it right, anyway.

Other engineers made similar comments: Initially, I tried to put everything into the classes that I could identify in my use case. I couldn’t imagine what other classes I would need and what classes are available in libraries.— I didn’t know how to improve or simplify my code and design. Our training was so basic that it taught us neither. — The graphical user interface was a bit easier because we had some examples to follow. — I spent most of the time getting the syntax right. I just kept on forgetting the semicolons and mistyping names of attributes and variables. And the UNIX workstation was absolutely killing us. It was so slow that by the time I could rerun my program I forgot what the change was about. — These problems are new to us. Our previous work was much simpler. It was individualistic even when working as a team, and the team was small. — I’ve been doing my maintenance work by myself. Seldom, would I ask for advice or help. But we know each other well. We’ve been working here for years and our work was very similar. — We’ve been successful in the past. This project was a completely new experience, a completely different game. It undermines confidence. — I think the consultant lost patience with us because he was expecting different questions from us. This technology is new to us, and we keep on asking him about those simple things, so he lost interest. He just tells us where to find an example or an explanation. So, I stopped asking him questions altogether. — Inheritance is a simple concept, but how to use it to simplify our work wasn’t. It was easy to identify the common objects but it took us time to come up with a hierarchy of classes. Actually, most of our object model is flat. — I am not familiar enough with the libraries. I don’t know what classes are there to extend. — I think I’ve learnt a lot, but I ain’t confident in my knowledge and work. We have no time to experiment and improve our code.

These problems affected performance of the whole P1 team and implementation of the system: We could have more team meetings scheduled in our project plan, but perhaps we didn’t need them either because we didn’t know what exactly we should discuss and what should we all know. — It took us a while to learn enough to start talking to one
another about the system.—Most of the time, I just sit at my PC trying to figure things out. Other guys are also like that. We hardly talk to each other. It’s tough.—We wasted so much time doing the same thing over and over because we couldn’t figure things out ahead of time. We have similar code all over the system.—One person should’ve come up with a concept, a framework. Instead, we were just told what to use to get it done.—No one ever said hey, let’s see how our code works together. I guess, no one had the confidence.—The integration was a nightmare. There were misfits everywhere, attributes, method signatures, types. In the end, we were just happy to get our code working any which way possible. Nobody dared to think about improving anything.—Maybe, we should’ve planned our work better. The first guy who cracked CORBA tried to explain to us how to build an interface, but it was hard to follow what he said because I haven’t looked into CORBA.—I haven’t read anything on CORBA before; I didn’t understand the concept. I’m not a networking person, either, but I wanted to learn how it works internally. I had to go through it all by myself step-by-step before I became confident. I used up too much time on it.—It took us a while to start thinking about the shadow process, the synchronization, and such things.

The P1 team members also shared their experiences and thoughts on managerial issues: Management just would not believe us when we said that we needed more time to learn. They said that we got all the necessary training, as recommended by the technology consultants.—Management says that projects require action on real tasks and application, not learning. Our project manager became angry by repeatedly telling us that he had ran out of excuses to justify the lack of progress to the customer.—Adding more engineers to the project helped reduce our workload, but it took time for them to catch up. We had to explain to them what to do, and we weren’t sure ourselves how to proceed. Needless to say, the UNIX workstation almost died under the workload. Now, there were twice as many people who had to learn something new rather than develop a system.—The learning curve was too steep, and by adding more people to the project we underwent two slowdowns in a short time. The new guys are OK, but we must explain to them what we do to make them productive as quickly as possible. We often engage in debates with them on what approach is better.—Too many things have been left to us to figure out. Our roles on the project should have been defined better, so that we all know who will
do what. We only focus on our own work most of the time.—There are too many new things to learn about. We spend most of the time thinking how to solve our individual problems. That’s what we talk about as a team, our individual problems.—Our customer tells me that the P2 team is much better than us. They are much better managed. Our manager only asks for more money, but we haven’t produced anything yet for them to see.—The [P2 project] manager does everything for his team. He writes code with them, he designs and tests the system just like all others. Our manager is a kind person, he is always first to come and last to leave the office, but I wish he could be more than just that.

We were also interested in the ongoing seminars in core competencies that had been offered by the corporation, and whether the P1 team members had participated: I got lots of training over the years as part of my personal development plan, but not much opportunity to apply it in my work. This project is the first opportunity for me to do something different and new since joining the company.—Initially, I was interested, but then I realized that I wasn’t using most of that knowledge in my work. This environment is static, the work we do hasn’t changed. This project is huge for us. Everything we do now is almost completely new to us.—The training program is really good. We can learn, for example, about new managerial methods and other things all the time, but the environment is as it is. We only provide IT services to our customers, and they prefer to do projects their way. In any case, we know them and they know us.—So far I haven’t acquired marketable experience, but there are many incentives to stay with the company, such as stock options, which bring significant benefits. There’s more job security than with other companies because the corporation has been doing well and expanding its businesses and operations all the time.—Generally, the work force here is static, and there are few possibilities to advance without relocating to another city or division, but only training is not enough.

P1 was completed about 2.5 months late, and the final cost was almost triple the original estimate, due to the addition of new personnel, poor quality, and slow progress. The P1 project manager never considered a change to the requirements without first consulting with his team and then asking for additional funding. The most prominent change requests that we know off were the new algorithm and the graphical user interface, and those came at additional cost to the customer. As mentioned above,
the P1 project manager was convinced that the monitors would all have the same resolution and size. Unfortunately, the cost of P1 escalated and there was no money left to purchase the new monitors, so the customer decided to purchase only one big new monitor for each stage and install cheaper monitors throughout the facility, which were not identical. As a result, the P1 team had to reimplement the graphical user interface in order to make it scalable. Although the P1 project manager knew that the P2 system had a scalable graphical user interface, he never consulted the P2 team on the matter. The P1 team did not reuse an existing layout manager, but developed their own that would only adjust all components to the monitor size and resolution at startup. This solution simplified the change and reduced the effort. It highlights the confidence that eventually developed within the P1 team and the talent that finally emerged.

Project 2: their own words
Due to persistent demands by operators, the senior management decided to introduce the table into the new system, along with the histogram. The P2 project manager treated that as a minor change request, because the data were already available and it was simply a matter of displaying them in a different view and in a new form. It took Mary less than a day to implement the change. (The P1 project manager treated that as a major change and rejected the request because the customer did not want to pay for it, but later he conceded.) The P2 team gave two demonstrations of the system before the handover, and they both went well, although there were some minor changes asked for because different people attended the presentations. During the handover, there were additional minor changes asked for because all the operators were present there at the same time and had engaged in a lively discussion until they reached a compromise on the graphical user interface and how the system should ideally behave. The P2 team remained open to suggestions and they were ready to oblige. After the handover, the P2 project manager commented that [he] would have to increase his team size by one or two engineers if the project would have lasted a month or two longer, because this team wouldn’t be able to cope with the pressure. They exceeded their limits! P2 completed on budget but three weeks late. It made almost no profit.
The other P2 team members also made a number of comments regarding their work on the project: This is not a large system, but I find it interesting. It has many external devices to account for, and each one is a bit different.— We prepared well for the project. Our design is simple and reusable, which makes our coding work easier.— Our project plan is really good, but there's a lot of pressure to do everything on time.— We lost too much time at the start of the project waiting for the other project to come up with something. Now, we have to work hard to make up for it.— I am paid by the hour, but the company doesn't pay for overtime work. We all work long hours.— We work well together and we figured out a great project plan. We figured out the dependencies. Only one person couldn't do it.— This team is all new, but we managed to bond easily. I guess it's also the work that has been interesting. We constantly add new features and play with our system all the time.— It's nice to see that what we have done actually works in the system. We add a little piece every day. We all test the system all the time, but we don't have to write test code. It saves us time and we do not overlook anything.— We're confident. We don't expect any problems with our system. It works just fine.— To me software engineering is about designing; it's a creative process. In the past, I enjoyed experimenting with new ideas so as to enhance my knowledge. This project requires a different mindset and constant interaction. First, I have to figure out the easiest way to accomplish my task. Then I have to analyze my design against the system together with my colleagues.— We must be careful and efficient because the schedule is tight. We have to be disciplined, and think as one.

The P2 team members also shared their experience and thoughts on their project manager: This project manager wants to keep everything simple, but I'd like to experiment a bit. I've been reading a lot on Object-oriented method and software systems, trying to keep my knowledge up-to-date.— It's a new experience for me, this obsession with simplicity. The project manager says that we have neither budget nor time for experimenting. On the other hand, we experiment with the way we use technology to help ourselves to advance faster.— Everything we do looks so straightforward and easy. Mary reviews our code and design, and makes them consistent, as if only one person wrote it. She is strict.— At first, I thought that our project manager dictates everything, even when technology was concerned. Then I realized that he only wants us all to
share the same vision and think how to get things done efficiently. Then, he'd let us to incorporate our ideas into the design.—In my experience, managers use only one process model for the project. This project manager has a passion for mixing things up. We use a different model for each phase.—This is supposed to be a waterfall project. Overall, it looks like it, but we use other models, too. We overlap a lot, individually, and as a team. We build incrementally.—Our project manager is very good at finding a compromise and problem solving. We never argue about anything.—We attack problems head on. The project manager would spot it soon, anyway, and start asking questions. He gets into everything.—At times, I wish I had more input. The project manager has figured out many things for us. He asks for our opinions, but it's his decision in the end. If he didn't like my estimate he'd always ask me to reconsider. Then, you decide, I said to him. He's never been assertive, though.—We work hard. The implementation gets frantic at times, but we're winning!

10 ANALYSIS
Projects are temporary and unique organizations formed to meet goals and bring about added value or beneficial change to all stakeholders. A project is characterized by its personnel, structure, task, and technology, which managers must constantly analyze, strategize for, and take actions in order to achieve goals. The software systems development process is a knowledge-intensive socio-technical system that can produce satisfactory results only when all the needed expertise and skills are available, coordinated, and integrated (Clegg et al. 1997), such as domain knowledge and skills, and the effects of a project's environment, job design, project management, and technology (Waterson et al. 2002). Knowledge is not absolute since it depends on a practice and a social context in which both explicit and tacit knowledge is conveyed through personal contacts (e.g., (Bresman 2010), (Brown and Duguid 1998)), and practices and strategies adopted and applied by project managers and teams vary across projects. When project managers and teams are capable and willing to approach projects and work with a desire to adapt, they can create new designs and possibilities that can make the project more likely to succeed (e.g., Kimbell 2009). The design perspective is: capable of accommodating multidisciplinary inputs; directed towards the generation of alternatives and a goal of joint optimization; explicitly
value directed; future oriented; oriented to a class of problems rather than one specific problem; and recursive, as problems are recycled as the design develops (Cherns 1973). In our analysis below, we find that the P2 project manager made use of these, whereas the P1 project manager did not, which, in our opinion, made their respective projects successful and unsuccessful—although both projects exceeded their cost and time estimates.

We begin this analysis by addressing the 10th success criterion in Table 1. The exercise of hard work and focus proved insufficient for this program to succeed. Both teams performed unevenly, but proved hardworking and determined to deliver a quality product to the customer, although their sources of difficulties, expectations for the outcome, and motivation for the effort were all different. The P1 team was saddled with a reactor strategy (Miles and Snow 1978), due to being low on exploitation and exploration. The P1 team could neither anticipate and plan for the future nor assess the present, and problems emerged as surprises for which there was not enough competence (i.e., abilities, knowledge, and skills (Lee et al. 1995)) and managerial savvy and willingness to deal with proactively. The P1 team first needed to acquire and develop solution domain competence, which became a challenge. The training was insufficient, and the lack of competence at both the engineering and the managerial level created other issues, such as the lack of a compelling vision, desire to adapt, and a fitting strategy; overstaffing; and poor collaboration and communication within the team. Yet, the P1 team did not lose their resolve to succeed because of their desire to broaden their competencies and their familiarity with the environment, whereas the P2 team developed the resolve because of the path the P2 project manager chartered for his team. He designed his project to succeed by opting for a defender strategy, i.e., by deliberately trading exploration for exploitation. The P2 designed simple solutions and executed tasks in a manner that geared the use of resources towards efficiency. The team focused on cost, proactive risk avoidance, quality, and results, and the P2 project manager engaged in a candid and receptive dialogue with the customer.

The P2 team was new to the environment, but to them and to IT3 this was just another software development project to work on. The P2 engineers lacked interest in the application domain, and they rarely
engaged outside the team because their peers at IT1 lacked solution domain competence. The P2 project manager responded by taking remedies that were enabled by the team size and justified by the tight budget. After a slow start, the P2 team managed to bond and work well together, being motivated by positive developments on the project, and leadership by the P2 project manager who was determined to lead a successful project in spite of difficulties and the epistemic divisions and politics between IT1 and IT3. It is likely that politics motivated the P1 team never to initiate a supplementary knowledge transfer between the two project teams, and the customer never to sympathize with the project teams that were both affected by insufficient hardware resources. Researchers have found that team leaders should engage in many different kinds of behaviors intended to foster team effectiveness, including arranging for the resources a team needs for its work and removing organizational roadblocks that impede the work, helping individual members strengthen their personal contributions to the team, structuring the team and establishing its purposes, and working with the team as a whole to help members use their collective resources well in pursuing team purposes (Hackman and Wageman 2005). However, in Table 1 the impact of leadership on project performance has not been ranked at all, and the competence criterion was ranked low although, on this program, it affected managerial decisions, performance expectations, and the teams’ behavior.

The performance expectations for P1 were not realistic, because the IT1 senior management underestimated the needs for training both in breadth and depth. It proved naïve to expect that the basic training sessions could prepare the P1 team for the paradigm shift such that they could undertake their work with the confidence and ease they were used to. Research has shown that a method learned from a crash course or a textbook is essentially based on topic knowledge, whereas software development requires episodic and topic knowledge (Robillard 1999). A learner experiences proactive interference when the existing knowledge that is now out of date interferes with the learning process because it is inappropriate in the new domain and, hence, a source of confusion and errors (Bjork 2011). The P1 team also lacked competence in software systems, for which they received no training at all. All these were not affected by user involvement, which explains the success of
the P2 team. In the environment where requirements were clear and stable, and application domain knowledge was readily available upon request, the P2 team had a clear advantage given their solid project management and solution domain competence. Although the IT3 senior management underestimated the effort required because the application domain was new to them, it did not make P2 unprofitable due to the goals and vision developed by the P2 project manager of a dependable system with a simple design within the shortest possible time, as well as his assessment of the solution domain competence of each P2 team member to which the project was adjusted. By contrast, the IT1 senior management expected that the competence of their personnel would be on a par with the challenge, but their vision of the new system, if any, certainly did not resemble the P2 project manager’s vision.

On this program, application domain knowledge played a lesser role than solution domain competence in two important aspects. Firstly, in this environment, application domain knowledge was available from many sources, and on P1 there was no shortage of it, including the project manager. The commanding application domain knowledge gave the P1 team the false impression that they knew all the answers. Customer participation was neither desirable nor necessary, because the P1 project manager perceived it as the main source of risk. He kept input by the customer to a minimum, justifying the strategy with his past experience when change requests bearing little significance undermined the project. These can explain why he was not concerned about the unfinished graphical user interface specification, and why the P1 team never felt compelled to stage a demonstration of the new system to the customer before the implementation was completed. The P2 project manager, by contrast, was open to customer’s input because the customer would decide whether to accept or reject the system. To him, working with a customer was unconditional. As a result of the opposite attitudes towards the customer, the level of customer involvement on the two projects became a matter of managerial preference. Secondly, P1 failed to make up for the lack of solution domain competence. At the start of the project, neither the P1 project manager nor his team knew how to design a project and a system for the new technology that would be tailored to their level of solution domain competence. The involvement of the consultants and experts was not beneficial until the team acquired
enough knowledge to integrate that expertise (e.g., Tiwana and McLean 2005), and it remained informal and limited. Therefore, P1 had nobody who could anticipate problems and shortcut their way out, let alone develop a design perspective, and the level of their competence affected the quality and span of their engagement.

Both project managers tried to avoid risk, but from a completely different viewpoint, which also revealed their different backgrounds, experience, and managerial preferences. For example, the P1 project manager’s preference for delegation was high, but his ability to integrate and unify was low, whereas the P2 project manager preferred moderate delegation and only when the goal was clearly established and its overall implications were understood by his team. Projects are exposed to risks driven by many factors originating from their changing and unique climate and environment, and proper planning and smaller project milestones are important success criteria (see Table 1). The roles of engineers and managers do not exist in isolation, and this awareness should be embodied by all team members, so as to share the mental model and internal ownership of the project. Mental models are a means by which individuals and organizations create and share meaning, thereby enabling a common understanding and the development of knowledge (Hill and Levenhagen 1995). The mental model of each individual can prove decisive for a project’s outcome, and even more so of a project manager. What many organizations call planning is simply a projection of their current mental models into the future (Arrango 1998), and [many] managers operate on mental representations of the environment that are likely to be of historical environments rather than of current ones, being first committed to policies and procedures (Kiesler and Sproull 1982). Our empirical study has taught us that, in order to manage a successful project, a project manager’s or a project management team’s competence should be broad and possess an all-inclusive attention to details. A project management team must assess the climate and environment, develop a new mental model, strategy, and vision, and design a project accordingly. The project manager must communicate these through various means back to the environment in order to gain and maintain the support of all stakeholders for the project.

In order to create a project plan, both project managers in this empirical study engaged the project team in the planning process, but the
engagement was not reciprocal. The P2 project manager made estimates together with his team and helped them with other work, whereas the P1 project manager could do neither. The P1 project manager was not familiar with the personnel and technology to design the project to facilitate the task. He neither asked for nor received any training that could help him manage this project. Instead, IT1 assumed that his past experience would suffice because this was the same application domain and environment and he was their most experienced project manager. The P1 project manager and his team did not develop a new mental model that would be appropriate for the project. The P1 software architect was new to the technology just as the team was, but they did not explicitly qualify this as a risk, even though they overestimated tasks to account for the learning needs. The P1 team assumed that the project was doable because they implemented the legacy system and the new technology was mature. IT1 believed that they provided ample external and internal support and good structure for both projects to succeed. In contrast to these, the P2 project manager initially found himself in an unenviable situation in which, besides being a newcomer, he had little control over and insight into his own project. The P2 project manager used his managerial and technology background and work ethics to turn the situation around. He identified multiple sources of risk, such as budgetary and scheduling constraints, personnel competence and their lack of motivation to acquire application domain knowledge, task complexity, and technology and its application. The P2 team utilized multiple risk management techniques, such as design for dependability, flexibility, maintainability, and to competence; dynamic process tailoring; prototyping; and ongoing system testing for the progress and quality monitoring. The P2 team worked diligently on the analysis and design so that they could define frequent milestones and smaller tasks. The P2 project manager was leading, whereas the P1 project manager was only observing his team’s effort.

Nevertheless, both project managers were determined to make the projects successful, but their individual contribution, influence, and involvement throughout the projects were different. The roles of the project manager and the software architect were assigned to different individuals on P1, which is common in the practice. But the separation raised here questions of influence and responsibility in those areas of
project planning and execution that required input from them both. For example, the P1 software architect did not think that his responsibilities included assessing the competencies of team members and reconciling them with the needs of the project, or enforcing that individual decisions meet a design goal. The P1 project manager never engaged in technology-related issues so as to exercise his own authority or influence, or form his own action plan or opinion. The lack of governance extended beyond the project team. The software technology experts were formally a high level technology management team who collaborated with the P1 software architect and the TCF team. They decided on the three-tier architecture for the new systems, selected the technology, and together with the TCF team designed the infrastructure and co-supervised its development. However, we learned that the software technology experts were not directly engaged in the other issues that affected P1. Consequently, the P1 team approached each use case independently, thereby creating an isomorphic team structure. Because there was no integrator or mentor among the project leaders, the design decisions and work allocations followed individual preferences. In his project plan, the P1 project manager assumed that each activity to implement a use case consisted of three tasks, i.e., a graphical user interface, a server, and a database task, and the estimates were made by those responsible for the use case implementation. Unfortunately, when tasks are not simple and well-defined, it is not easy to identify and understand which parts of the task affect the other parts (Espinosa et al. 2007), to learn, and to share.

Research has shown that a multi-stakeholder project must carefully position itself to its environment, and the goals and management methods of the project must be carefully matched with the context and the situation at hand (Karlos et al. 2008). Yet, the strategy adopted by the P1 project manager included a static project plan, and the waterfall model as suggested by his customer, both of which he grew accustomed to in the past. During the requirements elicitation phase, the P1 project manager engaged only those who worked on the task. The others were free to use their time to their liking or help with urgent tasks on other projects. Since they were not contractors but regular employees, their formal affiliation with P1 did not affect the budget because they were not doing billable work. Only the two novices had to acquire the application domain knowledge. This explains why Robert was available
to work fulltime on P2 requirements. The lack of urgency and targeted preparatory work for the implementation phase further weakened the performance of individuals and the P1 team. Even at the end of the project, the P1 team members could not explain to us much about the new system except for their own individual work and the difficulties they had experienced. All these factors led to poor control over the project, and limited their capability to deal with problems to the recruiting of more engineers to the team.

Both projects used the same quality procedures, such as change control, coding standards, formal control and planning tools, and formal reviews (e.g., McFarlan 1981). They used external and internal integration tools, such as a steering committee, formal approval process, and regular meetings and progress reports. The P1 team was fully accustomed to them, but the P2 team was not, and the external and internal environments of P2 were different. The P2 project manager faced three external sources of difficulties: the different business environments at IT1 and IT3, the unfamiliar application domain, and the politics between IT1 and IT3 regarding P2 cost and future distribution of business that was boosted by the lack of a governance structure. The P2 team was operating on its own, without the mandatory support from the other teams, and did not participate in the training for the P1 team, because IT3 assumed that they were all well versed in the technology. There was no application domain training because neither the customer nor IT1 would provide it. The customer knew that IT1 was familiar with their business and technological processes, and the outsourcing of P2 to IT3 was not their concern, which also explains why P2 lacked formal links with the customer. IT1 did not want to train IT3 personnel, arguing that the problem would be sorted out through reuse of their code and design, and IT3 treated P2 as a software problem. Internally, the P2 team had to be built because its members were unfamiliar, whereas the P1 team had strong ties, and knowing one’s teammates facilitates team performance (Harrison et al. 2003). IT1 and the customer had strong ties, whereas the P2 project manager and sponsor had to learn how to work together and with the customer. The P2 team building process was further hampered by the distance from the customer and IT1, which forced the P2 project manager to spend most of his time away from the team during his first month on the project.
The P2 project manager acquired his project management experience at various companies, and his technical background by working on a number of challenging software development projects. He was the only member of the P2 team without fundamental unknowns in the solution domain. He understood the concepts and the foundations behind the technology, and he knew how to use it for the benefit of the project. He used his broad competence in various ways: during his contacts with the customer he discussed and estimated change requests with confidence, and also helped in overcoming the customer’s lack of computer literacy; during the project planning he discussed estimates and identified task dependencies with his team, matched designs to skills and simplified tasks, and assigned roles and tasks so as to engage the team on broad issues; during the implementation phase he engaged in the solving of coding and design issues, and, finally, he motivated his team by demonstrating and explaining to them an easy way out, and led them towards the goal. Because he acted both as project manager and software architect, his plan for the project and the system encompassed the assessments of the development environment, the individual competences of his team members, and the tasks. He designed the project so as to minimize the exposure to such risks and was constantly looking for solutions that could improve the performance of his team. For example, Mary and Corey wanted to experiment with new ideas, but the P2 project manager repeatedly cautioned his team that their customer only wanted a dependable and fully functional system that was delivered on budget and time and not a state-of-the-art software design.

Both P1 and P2 were waterfall projects, but the P2 project manager tailored the process model as the environment and phases changed. By doing so, he controlled the cost and risk, improved the efficiency by overlapping activities, as well as utilizing incremental development, repetitive work, and simple architectural components that could be reused without modification, etc. His application domain knowledge was only emerging, but he did not hesitate to undertake a side project because that could be a good exercise and test for his team that could further boost the emerging positive image of IT3 with the customer... based on mutual respect and trust. During the requirements elicitation phase, the P2 project manager engaged his team on the analysis and design based on those P1 requirements that were completed and relevant to
P2. The P1 project manager did not have that opportunity, but his lack of urgency to engage the team early on in project related matters was, nevertheless, puzzling to us.

The P2 implementation phase consisted of short tasks and small increments, and most of the milestones took a week to reach because the schedule was tight. The architecture first strategy made work of the P2 team easier and interesting, and it facilitated quality because there was always a system to play with and test as they were implementing one use case at a time. By contrast, the software architecture on P1 only emerged at the end of the implementation phase, and the system remained riddled with problems and was unstable well into the testing phase. The P2 schedule included reciprocal tasks, but these tasks were mostly small and well defined, which made mutual adjustments easy to achieve, and gave the team the ability to integrate code into the system and test it without a delay. The P2 team was collocated and small, and it was not a problem to have tasks that required frequent communication and coordination. The P2 project manager demonstrated how to use managerial competence to tailor a project plan and strategy over time by nesting different process models and by instantly incorporating the learned lessons, instead of using only one strategy (i.e., the waterfall), as the P1 project manager had done. The P2 project manager also demonstrated how to use technology for the benefit of his team rather than letting it dominate the project. He took the internal project ownership upon himself, whereas on P1 it was never clear who was supposed to make project level decisions.

On the negative side, although the P2 project manager insisted that quality was everyone’s business including his, the P2 team lacked interest to delve deeper into the application domain and interact with the P1 team, for which they saw no value for their careers. They approached their work strictly as a software problem. When they did not understand something, they passed it on to the P2 project manager to provide the answer. Since the project was small enough for one person to grasp all of its aspects, being the liaison allowed the P2 project manager to gain full control of the project. Even so, all the P2 team members were familiar with the system because their project plan with short tasks and frequent milestones had teamwork in mind, i.e., it forced them to remain engaged, interact through their work products, and thus get to know the system.
and share expertise and ideas. The P2 team had no significant problems with the application domain, and the system handover and live testing went smoothly, which spoke to the clarity, quality, and stability of the requirements and the product. Given all these and because the lack of a vision negatively affected P1, we can conclude that the criterion of a clear vision proved more important than as suggested in Table 1.

The user involvement was important although, at times, their conduct and decisions could be questioned, such as the customer’s decision not to offer their hardware to speed up the implementation. This became even more puzzling after the hardware was provided for the side project; however, it was explained to us that TD purchased the personal computer and the board to connect a thermal probe to it. The goals (i.e., objectives in Table 1) and the scope were clear, but they were stable only for P1, whereas for P2 they changed as they learned about the environment and project, and after the projects split up. The proper planning and the smaller project milestones criteria were important on P2, whereas the P1 project manager lost control over his project and this was due to the unrealistic expectations regarding himself and his personnel. For the P1 team the learning curve during the implementation phase was steep, which affected their teamwork. The P2 team also experienced teamwork issues, both horizontally and vertically, which was due to teambuilding. Both projects enjoyed full senior management support, which was negatively affected by the governance issues.

The IT1 director was in rapport with the P1 project manager and, to the best of our knowledge, so did all teams at IT1 (see Figure 2). But the lack of engagement suggested that some roles were narrowly defined. The lack of clearly defined goals and roles and its negative effect on the performance of the P1 team persisted. On P2, the communication and the decision-making process between the project manager and the project sponsor took time to develop, which created intrateam issues. At times, the P2 sponsor expected feedback from the P2 project manager without asking for it, whereas the manager expected more credit and support from the sponsor. After a P2 governance structure was established, the tensions subsided, but the interteam governance issues persisted because IT3 neither officially announced who was the person in charge of P2 nor who was the P2 contact person. The IT1 director and the P1 project manager assumed that the P2 project sponsor was
the person in charge of P2 because *that was where the buck stopped*. For example, when the P2 project manager contacted the IT1 director via email he sent a reply to the P2 project sponsor, as if he had asked the question. These kept the P2 project manager out of the information loop and created unnecessary and unpleasant surprises.

It is worth establishing how the program affected the collective and individual learning in order to perform better the next time. As one can conclude from the feedback that we collected in our interviews, the P1 team members were not convinced that the newly acquired competence had sufficiently developed to make them confident that their future assignments would fare significantly better. To them, the project was too difficult to consider alternatives and contemplate improvements. By contrast, some P2 team members were disappointed that they could not be more creative, but they appreciated that they managed to complete the project on budget. They argued that *they would not have missed the deadline if they could have started the implementation as originally planned.*

It was interesting to notice that the P1 project manager appointed Robert as the new customer liaison instead of Shane. When asked to comment on his decision, the P1 project manager replied that *Robert had more experience*, but it was difficult to conclude whether the whole episode points to single loop learning (Argyris and Schön 1978), or is merely an unreflective action taking (Fiol and Lyles 1985). Nevertheless, both Robert and Shane had arguably done an excellent job on requirements, just as they had spent years working well for the same customer. To the best of our knowledge, the customer senior management did not perceive the problems that burdened P1 as Shane’s mistakes. They did not attribute the graphical user interface problems to him, just as they did not attribute the accomplishments of the P2 team with their graphical user interface to Robert, because he neither suggested to build a prototype, nor got involved in any of the subsequent change requests. The customer was aware that those decisions were influenced or made by the respective project managers, and they noticed the difference in the approach and conduct that they experienced while working with the two.

Finally, we describe the impact that the two projects had on IT1 and IT3. Upon implementing P2, IT3 took advantage of the fact that IT1 was still busy working on P1 and engaged in another project for another in-house customer that had also been processing raw materials.
That customer was located in another province, but IT1 maintained the system. The project was nearly identical to P1 because the customer had only one stage, which was similar to Stage 1, but its processing capacity was smaller. The customer appointed a new project manager (NPM) who had an office at IT1, and he consulted the IT1 management for advice. The P2 project manager initiated the negotiations, and together with the P2 project sponsor negotiated the terms with the NPM. This became a greenfield project, and the NPM asked IT3 to allocate eight engineers to the project, with IT3 being happy to oblige. The P2 team was assigned to the new project with the exception of the P2 project manager, who remained with P2 until the system handover was completed and his contract with IT3 expired. The NPM rehired the TCF team leader who became the technical leader for the project and the team leader in charge of the eight engineers at IT3. After completing P1, the P1 project manager became responsible for the development of a new system for Stage 3. The Stage 3 project was fixed priced, and for which the P1 team shrank down to six engineers. The P1 project manager decided to move from the cubicle back to his office, and the P1 software architect decided to rejoin IT2.

11 CONCLUSIONS
The literature concerning software development projects has mostly focused on a specific aspect, and its presentation has been weak on details, particularly in quantitative empirical studies. For example, the key constructs derived from project management literature were characterized by such terms as inadequate project milestones, poor control, poor customer relations and specification, properly planned, and underestimation of resources. All, any, or a combination of some of these can affect software projects; but because they require a context, we wanted to address two issues that remained vague: a) how or why something happened, and b) what was or was not done to anticipate, identify and resolve issues, so that we could connect the cause and effect with the stakeholders and environment. For example, project size is a complex factor. In this study, the size estimates were often based on the insufficient understanding of issues or needs, which extended to other decisions. In the analysis, we verified whether our findings were backed up by relevant research and theories, and if the knowledge to
avoid or overcome the issues was available. By doing so, we assisted the corporation in improving their organizational learning program.

In the domain of work, the model of technical work and techniques has monopolized discussion in the business and organizational literature since Taylor, at the expense of our understanding of practice (Orr 1998). The best choice is one that jointly optimizes both the social and the technical systems (Cherns 1973). On these two reengineering projects, we found that the managerial and engineering roles could not be separated. It was hard to manage the systems project with little or no understanding of how to design the jobs, the structure, and the system, and use the new technology to fit the project and meet the needs of all stakeholders. One team was familiar with the customer and knew the legacy systems inside out, and had external and some important internal integration tools, all of which the other team lacked. The familiar team finished the project significantly behind schedule and over budget, and the other was only late. Instead of a single criterion in Table 1, a combination of criteria proved decisive. Both projects met criteria 1, 2, 3, 8 and 10 (59% project success ratio). Both teams missed criterion 7. They diverged on criteria 4, 6, and 9 (0 or 23% project success ratio). An important finding is that Criterion 5 remained inconclusive, because different time or view points gave different answers that were all related. For example, a poor assessment led to a poor decision or unrealistic estimate; the insufficient training was a team performance obstacle; and the size difference between the two projects and its evolution rendered the managerial expectations relative.

We find this evaluation credible and relevant because the projects developed nearly identical systems in a natural setting, and used the same methods and tools. We also find this evaluation inconclusive, as Table 1 missed criteria such as mismanaged decisions and issues within a team. An important finding of this study is that the strengths and weaknesses applied equally to the engineers and to the managers. The stakeholders sometimes acted counterintuitively to an observer, because the governance structure either took time to develop or was missing. The individual competence and experience of the managers became a major factor in the outcome, such that, from the very start, the two project managers were in charge of two different projects, but for different reasons. The initial plan for reuse to cut cost became infeasible and
the projects diverged, with each reflecting the background, engagement, influence, and mental model of the manager. While the familiar project manager primarily reacted to developments on the project and avoided change, the other project manager found change unavoidable and tried to act proactively. The individual competence and experience shaped the ability to develop a comprehensive project plan, the anticipation and perception of events, and the involvement in the process of seeking resolutions to challenges and risks experienced on the project. Change on a project can come from many sources, and professionals should possess the ability to cope with changing and complex environments (Bassellier and Benbasat 2004). If change does not necessarily imply learning, adopting new technologies certainly requires it. Project managers should possess competence in dealing with nonroutine problems and tasks and in finding ways of linking business and technology goals. In this evaluation, the success of the other project gained significance.

We found that competence, objectives, and vision deserve much more attention than is suggested in Table 1. The project with more solution domain competence had a clear advantage in criteria 4, 5, 6, 7, 9, and 10, which commands further research at all organizational levels and from multiple viewpoints. We found that creativity, decision making, and experimentation required competence, control, and direction (i.e., criteria 4, 6, 7, and 9) in order to become beneficial for all stakeholders. Organizational adaptation and learning require a concerted effort, and a proper environment and strategies. The failure or success of a project becomes even more relative when it deals with a domain or technology that is of strategic importance for the company. If the personnel neither develops nor feels confident about competence in either of the domains, then the company has not fully profited, irrespective of what the outcome was. Software systems development is much more than programming. It is a systems problem and scattered interventions cannot significantly enhance overall project performance and the quality of the final product. Some of the techniques used by the other project were well known, such as the incremental development, and the ongoing testing for control and quality. The overlapping of phases was used for better resource utilization and schedule compression. Novel ideas emerged that require attention in our future work, such as strategizing for the purpose of dealing with personnel, task, and technology risks by the use of software
architecting and designing, overlapping projects for cost cutting, nesting of process models, and dynamic process tailoring.

Our assessment of the program, according to Table 1, put the prospect of successful outcome at 60%, yet it missed expectations. Only by examining the four interdependent variables that characterize socio-technical systems (i.e., personnel, structure, task, and technology) can one appreciate the curious and surprising outcome of the program. Managers can control and plan for these four variables only when they are familiar with all of them. We do not suggest that the project manager be responsible for all four variables, but the project management team must be. In this study both scenarios could be studied, and the other project manager became the difference-maker in the performance of the two projects. The two systems were relatively modest in size and in their use of software technology, but were nevertheless complex due to their environment and requirements. Size and technology became important because a person with both engineering and managerial competence could grasp the whole environment and project, catch up with the new knowledge areas, and develop a plan and vision of a successful project. In the end, both systems were handed over to the customer, who was neither satisfied with the cost nor lead time. The outcome and aftermath of the projects also revealed the breadth and depth of collective and individual involvement, knowledge, and learning at all the levels, as well as the management concerns and practices that did not favor the customer.

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Questions

<table>
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<tr>
<th>No</th>
<th>Question</th>
<th>Comment</th>
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<tbody>
<tr>
<td>1</td>
<td>How did the P2 team test the system?</td>
<td>• Was quality the only objective? What other benefits and considerations were taken into account?</td>
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<td></td>
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<td>• Did testing affect the project insight?</td>
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<td>• How would you argue against or for this strategy as a project manager and as an engineer?</td>
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<td></td>
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<td>• Compare this strategy with some other you are familiar with, such as the test-first programming concepts?</td>
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<tr>
<td>2</td>
<td>What mechanisms were put in place to motivate employees to advance their competencies and stay with the corporation?</td>
<td>• Describe the model at different organizational levels.</td>
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<td>• Do you think it provided expected benefits to the employees and the corporation?</td>
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<td>• Is it better to outsource training or use internal instructors?</td>
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<td>• How would you define the core competence at each organizational level mentioned in the study?</td>
</tr>
<tr>
<td>3</td>
<td>As a project manager, how would you avoid or overcome the difficulties experienced by the P1 team?</td>
<td>• What competencies would you need?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• What strategy would you use?</td>
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<td></td>
<td></td>
<td>• How would you get the other IT1 teams to more productively contribute to the P1 team?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• How would you know that your peers and subordinates are on par with the challenge?</td>
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</table>

Exercises

Exercise 1: Employee Competence

For an organization to become successful its employees should possess the competencies that match the challenge. How would you ensure, through recruitment, selection, and training that employees can indeed perform as expected? If you were the IT1 director, how would you go about preparing and staffing the P1 team? If you were the P2 sponsor, how would you negotiate P2? What would you need to know to ask the right questions or solicit the right advice?
Exercise 2: Project Environment
How would you improve the contributions and relationships between the teams singled out in the empirical study? How would you engage the teams to achieve the goals, namely cost, quality, reuse, and schedule? Would you consider a different strategy instead of having two (independent) projects? What managerial and/or other competence would you need to have to implement your ideas?

Comments
You can consult the articles listed below under Further Reading before working on the exercises.

Further Reading
The following paper investigates the problem of organizational learning and software systems development over the course of multiple concurrent and successive projects within the same division of a telecommunications corporation.

In this chapter, the authors also tackled problems that were related to organizational practices and processes. The following two articles are recommended not to promote lean, but as an attempt to paint a broader picture if not to look at the totality of the problem, both of which has been seldom the case. The articles provide another take at how systems approach and thinking can change and shape the corporation and industry, and facilitate transfer of knowledge between industries. These articles testify that problems that burden the software systems development are common across engineering disciplines and industries, and the manager could have even more challenges to deal with and overcome. Some have been more successful at tackling problems while others have been lagging behind despite advances.
ONLINE CONSUMERS ENGAGEMENT ON FACEBOOK BRAND PAGES
THE CASE OF THE AUTOMOBILE INDUSTRY

LEARNING OBJECTIVES
The objective of this chapter is to examine the relationship between social networking sites and online consumer engagement. Once you have mastered the materials in this chapter, you will be able to:

• Explain the significance of social media and social network sites for businesses.
• Understand the role of Facebook brand pages and brand posts in communication with consumers.
• Understand the concepts of consumer engagement and online consumer engagement.
• Explain the characteristics of the generated contents by firms on Facebook brand pages.
• Understand what kind of contents could motivate the Facebook users.

CHAPTER OUTLINE
Companies aim to peak consumer engagement with their social media with the brand posts they create on Facebook, one of the most utilized social media application. Reactions of the consumers towards the brand posts of the companies are realized as three basic functions which are likes, comments, and shares; and thus the online consumer engagement (OCE) takes shape. This chapter examines the effects of the posts made on brand pages of the automotive sector companies in Turkey on OCE according to their contents (entertaining, informative, rewarding),
media type (interactivity, vividness), and timing (day, hour). Necessary data were collected about the brand pages and user interactions of five brands which constitute 55% of the total personal automobile sales in the year 2015 in Turkey. The findings show that vividness of the brand post, informative and entertaining content and, working hour of users were observed to have significant effects on customers’ reactions.

**KEYWORDS**
Facebook Brand Pages, Consumer Engagement, Social Networks, Negative Binomial Regression

**1 INTRODUCTION**

Developments in communication technology and social media applications make possible to contact more efficient and interactive relationships with customers of the companies. This chapter focuses on concepts of social media, social networks, and Facebook brand pages. The characteristics (media type, contents, and time) of the brand posts in Facebook created by companies and online consumer engagement concepts are explained. Then the effects of brand posts created by the companies on online consumer engagement are analyzed.

On the contrary the traditional media, social media and social networks present companies the opportunity to be in interactive dialog with their consumers regardless of the time and place (Phillips & Young, 2009, p. 6; Clark & Melancon, 2013, p. 132). Companies, besides using social networks to build new relationships and connect more effectively with their consumers, also benefit from social networks for distributing information about their products or services virally (Dobele, et al., 2007).

While social networks are systems that allow the consumers to chat with their families and friends, they also present an environment in which they can interact with both companies and other consumers. Consumers, by liking, commenting on, and sharing the companies’ posts, put the companies beyond just a place where they shop from, and engage with them (Al-Deen and Hendricks, 2013, p. 4). One of the sectors in which the online consumer engagement is realized the most is the automobile sector (McCulloch, 2015). Automobile sector, a very significant industry in Turkey, displays its presence in online media noticeably and Facebook brand pages are followed by millions of people. The companies in the automobile sector keep appearing before
the consumers with new posts, and in return get likes, comments and shares from them.

In the study, assuming that the five companies which constitute 55% of the total personal automobile sales in 2015 represent the sector, detailed data were collected about their brand pages and user interactions for four months. Analyzing the obtained data, the answers were sought to the questions of (i) how the interactivity and vividness affect OCE as a media type, (ii) which one of the entertaining, informative, and rewarding contents has more effect on OCE, and (iii) whether the work days or after hours have any effect on OCE. Negative Binomial Regression Model was used for analyzing the data and the obtained results were construed.

2 SOCIAL MEDIA AND CONSUMER ENGAGEMENT

2.1 Social Media and Social Networks
Marketing communication professionals have various and brand-new tool to reach today's consumers and maintain a constant communication. Social media, which consists of internet-based applications, technology of which is based on Web 2.0, is among the most important ones of these instruments (Berthon, Pitt, Plangger, & Shapiro, 2012, p. 263). Social media makes the access possible to the customers any time the connection is on, transmits the messages, and increases feedbacks (Mudambi & Schuff, 2010, p. 185). Social media, which encourages the shifting of the power in the market from the businesses to the consumer (O'Brien, 2011, p. 32), also presents various opportunities for those who determine the marketing strategies (Liu-Thompkins & Rogerson, 2012, p. 79).

Roots of the social network sites go back to the Computerized Information System of the 1980s (Zarella, 2009). The first instance of the social networks as we understand them today was SixDegree.com which was founded in 1997. Released in 2004 at a University in the USA, Facebook spread rapidly and now draws great interest from today's social network users (Ellison, 2007, p. 214, 218). As well as having the highest numbers of users among social networks, Facebook also manipulates 50% of the social media market (Kallas, 2013).

Social media consists of internet-based applications that include virtual world tools which would provide communication with consumers.
such as blog, microblog, social network, media sharing, social news and tagging, voting and rating, or forums. (Zarella, 2009). Social networks are web-based services that allow persons to create an open or semi-open profile, list the profiles of other connected users within the same system, and display their or other users’ profiles within a limited system (Ellison, 2007, p. 211). Compared to other communication instruments, social networks draw attention with 1.3 billions of active users (Facebook, 2014) according to the data of U.S. America Census Bureau (Kemp, 2014).

2.2 Facebook Brand Pages
Facebook has a form that keeps together the features of creating personal information profiles, sending invitations for accessing the profiles of online persons such as colleagues or friends, and sending e-mails or instant messages (Kaplan & Haenlein, 2010, p. 63). On Facebook, companies can create profiles just like persons can. The pages with the corporate profiles of the companies are called brand pages (Richter, 2011, p. 98). Companies create and manage their brand pages for the purposes of communicating with their customers, maintaining the communication, customer notification, benefiting from word-of-mouth communication, increasing customer loyalty, making the customers defenders of the companies, etc. Companies are able to make brand posts of different contents (entertaining, informative, rewarding), and different types such as video, photograph, link, event, and status on their brand pages they designed according to their goals.

In accordance with the communication policies of the companies, brand pages aim to send contents to the consumers’ personal profiles, to have the contents liked by the users, to have them commented on, and to have them shared (Cvijikj, 2013, p. 846). Thanks to the brand pages, users and consumers are able to transmit their reactions, opinions, and views about the companies to other consumers and to the companies themselves. Interactions that users and consumers do on Facebook indicate their online engagement with the companies, as well as providing the companies with instant feedback.
2.3 Consumer Engagement

In recent years, consumer engagement is an attractive concept in marketing literature. A research made by MSI Research Priorities (2010) showed that it was one of the most studied concept in understanding consumer behaviors and experiences. Consumer engagement is also considered as a vital component of relationship marketing (Vivek, Beatty, & Morgan, 2012, p. 122). In the interactive and dynamic business environment, consumer engagement is seen as a necessity constituting the company performance, increasing sales, providing competitive advantage and its effect on profits (Tang, 2013).

Consumer engagement is described as participation of consumers in notifications and activities of companies, and their frequency of constant communication (Vivek, 2009, p. 7). Consumer engagement affects the development of different attitudes and behaviors as well as it affect the purchases towards the companies’ products (Van Doorn, et al., 2010, p. 254). Further than constituting consumer loyalty based on logical reasons, consumer engagement is explained by Mollen and Wilson (2010:919) as repeated interactions between consumer and brand which constitute strong emotional, psychological ties or physical investments. At the same time these interactions create competitive advantage by providing protective effects on sales. Social media increases success in engagement offers many opportunities for the interest of the company and provide customers with continuous access to updated content and active communication (Zailskaitė-Jakštė & Kuvykaite, 2012, p. 194).

In social networks, consumer engagement is realized as liking, commenting, and sharing (Shu-Chuan Chu, 2011, p. 49). In evaluation of the companies’ performances in consumer engagement, the likes, comments, and shares they receive in return of their posts on brand pages are taken into consideration. In making the consumers take action, the media type (interactivity, vividness), content (entertaining, informative, rewarding), and timing (day and hour) of the brand posts designed for the brand pages are determinant (Cvijikj, 2013; De Vries, 2012).

Companies are able to verify consumer engagement at social media using Facebook brand pages. Consumers can engage by reading content created by companies and consuming, discussing and sharing with other users at different levels (Heinonen, 2011, s. 356; André, 2015, s. 113).
12). Consumers can show their engagement by getting in contact with companies through processes done (like, comment, share) on companies’ brand pages online.

The content properties (vividness, interactivity, informative content, entertainment, position, value of comments, day of the week, length of messages, product category) put on Facebook brand pages can effect the user processes in different ways (De Vries, 2012). These effects can be studied in subcategories such as the media type, content and creating time. Media types (video, photograph, link, status, event), interactivity and vividness of the content can effect the consumer engagement in different countries (cultures) at various levels. For instance, whilst in India, the most effective media type is photographs on OCE (Jayasingh & Venkatesh, 2015, p. 24), studies done in other countries show that video contents are more effective than photographs (Cvijikj, 2013, p. 859; Golshani, 2015, p. 30).

Socialization, entertainment, rewards, identity seek and information search reserve quite a ground in users’ social network interaction and OCE motivation (Park, Kee, & Valenzuela, 2009, p. 729; Heinonen, 2011, p. 359; André, 2015, p. 13; Lin & Lu, 2011, p. 1152). Besides, the quality of the products the consumers are interested in is a determinant. While consumers in favor of buying specialty products search information about and compare the properties of products such as the quality, and price, for convenience products the use of social network is realized through entertainment request (Gonzalez, 2013, p. 24).

Another factor that effects the user perception is the sequence of the products on Facebook brand pages. Users see the newer contents up in the page in sequence of time. Having high visibility on web-sites creates an advertisement effect like prime-time on TV, which is more precious than other times (Rowse, 2006). The plenty time users have provide an increase in OCE on brand pages.

Consumer engagement, having a great deal in modern company policies, can be realized swiftly and smoothly through social network and brand pages without time and place restraints. However, creating the objective effect on consumers and increasing OCE depend on factors like media type, content, and the creating time of the post. In this study, automobiles on the popular automobile Facebook brand pages in Turkey
are surveyed as favorable products. In this concept, media type, content, creating time of the post is studied on the effect on OCE.

2.3.1 Media Type
Media type used in the brand posts describes the interactivity and vividness dimensions of the post. Vividness reflects the richness and attractiveness of the content the media type includes (Steuer, 1992, p. 83). Interactivity includes the participation to the mutual communication with the users depending on the content (Chi, 2011, p. 47). Media types sent to Facebook brand pages specifically consist of status, photographs, events, and videos.

More vivid media types on brand pages are expected to draw more attention from the users and increase engagement. Similar to the results of the researches made upon web sites, vividness is seen to have an increasing and positive effect on consumer engagement (Coyle & Thorson, 2001, p. 75). On the other hand, it may be possible that the media with vivid and attractive contents receive more clicks, meaning a higher interactivity for them (Rosenkrans, 2009, p. 18). However, sometimes higher interactivity may precede the content, causing the user to skip to other sites and subjects and alienate from the engagement. Within the framework of these statements, the below hypotheses are developed:

- H1a: OCE is higher in highly vivid posts.
- H1b: OCE is lower in highly interactive posts.

2.3.2 Content
Posts designed by the brand pages can be basically categorized as entertaining, informative, and rewarding. Users first react to entertaining contents (Phelps, Lewis, Mobilio, Perry, & Raman, 2004, p. 343), and then they react to informative ones (Park, Kee, & Valenzuela, 2009, p. 731). Rewarding contents come in third after the other two, and cause lower consumer engagement. This fact may vary for other sectors but according to the results of the previous study, in the automobile sector, entertaining, informative, and rewarding contents are respectively expected to increase consumer engagement. Within this framework the below hypotheses are developed:

- H2a: OCE is highest in entertaining contents.
• H2b: OCE in informative contents is lower than entertaining contents yet higher than rewarding contents.

2.3.3 Time
Evaluations made toward the time dimension in social media usage indicate that certain days and hours are more suitable for posting in social media instruments because of the volume of usage. Although there is a concurrence on that the work days are more suitable for posting on Facebook, there are different opinions as to which hours of the day are more suitable (06:00–08:00, 14:00–17:00 and 11:00, 15:00, 20:00) (Warren, 2010; Campbell, 2013). Criticality of the time dimension results from that Facebook positions the most up-to-date post on the top while displaying it. The fact that many friends and other companies contents are on the profiles of the users may cause the post to stay low and less visible. Although users are able to connect the social networks anytime anywhere where the connection is available, they may tend to frequent at certain hours.

Brand posts on Facebook are shared more on workdays compared to the other days (Kallas, Don't Post on Friday, 4PM, 2010) and are significantly followed by the users who are on their way to their homes after the work hours. It is deemed possible that the consumer engagement for the posts designed by automobile brands is more effectively realized on work days and especially during the peak hour’s right after work. The below hypotheses are formed in order to test this possibility.

• H3a: OCE is the highest on work days.
• H3b: OCE is the highest during the three hours following the work hours (17:00, 18:00, and 19:00).

A research model is designed in which the relationships and the hypotheses mounted within the framework of the above statements are summarized. Research model of the study is presented in the Figure 1.
3 PURPOSE AND PAPER OUTLINE

3.1 Purpose of the Study
This study examined the effects of brand pages that play a critical role for the companies in the automobile sector in Turkey, in communication with consumers, increasing the communication quality and maintaining the communication, and benefiting from word-of-mouth communication (viral). Brand posts the automobile brands made on these pages and reactions of the users (likes, comments, shares) to these posts on Facebook were examined for a period of four months, and the effects of media type, content, and time of the posts to consumer engagement were researched.

OCE aims to provide the companies more effective communication with the consumers, which means forming new communications, spreading the created messages rapidly and virally for a low cost compared to the traditional media, increasing the customer loyalty, and making the customers into defenders of the company. Because of
these functions it has, importance of OCE is increasing by day. In this scope, this research which, was conducted within the framework of a descriptive research design, offers a significant contribution with its deductions for automobile brand pages in the framework of the obtained results.

Although theoretic researches about OCE that were conducted towards blogs, web sites, and social media instruments (Mollen and Wilson, 2010; Brodie, et al., 2013; Zailskaitė-Jakste and Kuvykaite, 2012; Wirtz, et al., 2013) and empirical studies that were conducted using Facebook brand pages (Cvijikj and Michahelles, 2013; De Vries, et al., 2012) exist, studies towards the brand pages of the automobile companies in Turkey are very limited. In this respect, the study also is important for being an empirical study based on data obtained from the Facebook in a sector and country that had not been studied before.

In the study, data of the five companies that made the most personal automobile sales in 2015 in Turkey were examined. The companies are, respectively, Volkswagen (Sales Figure: 139.043), Ford (Sales Figure: 118.640), Renault (Sales Figure: 117.363), Fiat (Sales Figure: 109.490), and Hyundai (Sales Figure: 51.743). The total sales figures of the five companies constitute 55% of the total private automobile sales of the year 2015 (968.017) and is assumed to represent the automotive sector in the study (ODD-Automotive Distributors Association-, 2016).

Brand posts of the five companies on their brand pages were examined between October 1st and December 31st. The analysis process; data of types, contents, posting times, likes, comments, shares, views of the total of 417 posts, and what time the users commented on these posts were used. Numbers of views were obtained by the relevant post being opened, and the other data were obtained via Facebook Graph API application between March 2nd and April 1st 2015.

In determining the vividness and interactivity factors of the media types belonging to the brand posts, the method in the Table 1 which, has examples in the literature, was taken as the basis (Cvijikj and Michahelles, 2013; De Vries, et al., 2012).
Table 1  Vividness and Interactivity Dimensions of Media Types

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<th>Media Type</th>
<th>Interactivity</th>
<th>Vividness</th>
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<tr>
<td>Video</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Link, Event</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Photograph</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Status</td>
<td>Low</td>
<td>Low</td>
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While determining the factors of the post content, the posts that talk about the brand, the company, products, or services are accepted to be informative; and those that talk about lotteries, tickets, rewards, credit points, etc. are accepted to be rewarding. The contents that remain out of these are accepted to be entertaining (Cvijikj and Michahelles, 2013). Examples of contents are given in the Table 2.

Table 2  Examples of Contents

| Entertaining | It’s snowing! Leave little trails that give happiness to those around you. :)  
(Volkswagen, December 30th 2015) |
| Informative | It’s just the time to get a Freemont, Panda, or Punto from Fiat! Your dream Fiat models wait for you in our showrooms with special year-end discounts!  
(Fiat, November 18th 2015) |
| Rewarding   | Kadjar invites you to the adventure! On October 27th, catch the chance to win your special Hobby pass code for the draw with Shazam in Love Again! #seyircikalma  
(Renault, October 25th 2015) |
Dependent variables used in the study qualify as count data. The most commonly used method for explaining the relation between dependent and independent variables (count data) is the Poisson Regression Analysis. The most significant constraint of the Poisson Regression Analysis is that the variance and the average must be equal. In cases when the Poisson dispersion indicates over dispersion, in other words when the dispersion variance is higher than the average, Negative Binomial Regression is used (Sezgin and Deniz, 2004). In the study, first the suitability of the Poisson Regression analysis was checked, and because the dispersion variance was higher than the average (Table 3), Negative Regression Analysis method according to the equation (1) was preferred.

In the equation (1), indicates the figures of likes, comments, and shares, which are dependent variables. The other variables (independent); “media type” indicates the media type of the post, “content type” indicates the content type of the post, “work days” indicates the posts created during work days, and “work-end” indicates the posts created following the work hours (17:00, 18:00, 19:00).

Table 3  Average and Variance Values

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<th>Average</th>
<th>Variance</th>
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<tr>
<td>Likes</td>
<td>5425.35</td>
<td>65703843.234</td>
</tr>
<tr>
<td>Comments</td>
<td>95.16</td>
<td>27509.940</td>
</tr>
<tr>
<td>Shares</td>
<td>150.55</td>
<td>111956.671</td>
</tr>
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Negative Binomial Regression analysis was repeated three times in order to determine the relations with the dependent variables of likes, comments, and shares. Following the conducted analyses, chi-square values that indicate the relevance of the models that test the relation between the dependent variables of likes, comments, and shares and examined independent variables were summarized in the table 4. The results show that the models are statically relevant as a whole.
Table 4  Chi-square, Significance Values

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<thead>
<tr>
<th></th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likes</td>
<td>83.780 .000</td>
</tr>
<tr>
<td>Comments</td>
<td>39.627 .000</td>
</tr>
<tr>
<td>Shares</td>
<td>462.128 .000</td>
</tr>
</tbody>
</table>

\[df = 6, N = 417\]

4  FINDINGS

4.1  Descriptive Statistics

The five companies which achieved the most sales figures in automotive sector in 2015 are respectively Volkswagen, Renault, Ford, Fiat, and Hyundai (ODD, 2016). The numbers of likes the brand pages (vwturkiye, renaulturkiye, fordturkiye, fiatturkiye, hyundaiturkiye) of these companies received were obtained by using their Facebook Graph API application. However, because the number of likes the Volkswagen Turkey page received was abnormally higher than the other companies and the page was exactly the same with Volkswagen Australia page, the number of likes from only Turkey each company received were observed via SocialBreakers.com. The average number of likes for the automotive sector brands is 1,696,276 (Facebook Stats in Turkey, 2016). Considering the brand page likes, Volkswagen and Renault are above the sector average, while Ford, Fiat, and Hyundai are below the average. During the period of the study, averages of 83 posts were made on the brand pages of the companies. While Volkswagen, Ford, and Hyundai have above-average number of posts, Renault and Fiat are below the average. During the period of the study, an average of one post in one and a half day was made in the automotive sector (Table 5).
Table 5  Automotive Sector Brand Pages and Numbers of Posts

<table>
<thead>
<tr>
<th></th>
<th>Page Likes</th>
<th>Page Likes (Local)</th>
<th>Total Posts</th>
<th>Post Frequency (122 Days/Total Posts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector Average</td>
<td>6,055,083</td>
<td>1,696,276</td>
<td>83</td>
<td>1.67</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>25,371,110</td>
<td>3,701,604</td>
<td>97</td>
<td>1.26</td>
</tr>
<tr>
<td>Renault</td>
<td>2,079,854</td>
<td>2,012,284</td>
<td>48</td>
<td>2.54</td>
</tr>
<tr>
<td>Ford</td>
<td>597,228</td>
<td>585,789</td>
<td>109</td>
<td>1.12</td>
</tr>
<tr>
<td>Fiat</td>
<td>1,028,115</td>
<td>994,112</td>
<td>52</td>
<td>2.35</td>
</tr>
<tr>
<td>Hyundai</td>
<td>1,199,110</td>
<td>1,187,589</td>
<td>111</td>
<td>1.10</td>
</tr>
</tbody>
</table>

65 (76%) of the posts the brands in the automotive sector made during the study period are photographs, 13 (17%) are videos, and 5 (6%) are links. All brands, particularly Ford and Hyundai used photograph post type intensively. Video post type was used most frequently by Volkswagen, and the link post type was most frequently used by Renault (Table 6).
Table 6  Post Types ad Frequencies of Automotive Sector Brands

<table>
<thead>
<tr>
<th>Sector Average</th>
<th>Total Posts</th>
<th>Video</th>
<th>Photo</th>
<th>Link</th>
<th>Event</th>
<th>Video</th>
<th>Photo</th>
<th>Link</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>83</td>
<td>13</td>
<td>65</td>
<td>5</td>
<td>0</td>
<td>0.17</td>
<td>0.76</td>
<td>0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>97</td>
<td>25</td>
<td>66</td>
<td>6</td>
<td>0</td>
<td>0.26</td>
<td>0.68</td>
<td>0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>Renault</td>
<td>48</td>
<td>11</td>
<td>31</td>
<td>6</td>
<td>0</td>
<td>0.23</td>
<td>0.65</td>
<td>0.13</td>
<td>0.00</td>
</tr>
<tr>
<td>Ford</td>
<td>109</td>
<td>9</td>
<td>95</td>
<td>5</td>
<td>0</td>
<td>0.08</td>
<td>0.87</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>Fiat</td>
<td>52</td>
<td>10</td>
<td>40</td>
<td>1</td>
<td>1</td>
<td>0.19</td>
<td>0.77</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Hyundai</td>
<td>111</td>
<td>9</td>
<td>94</td>
<td>8</td>
<td>0</td>
<td>0.08</td>
<td>0.85</td>
<td>0.07</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>417</td>
<td>64</td>
<td>326</td>
<td>26</td>
<td>1</td>
<td>0.08</td>
<td>0.85</td>
<td>0.07</td>
<td>0.00</td>
</tr>
</tbody>
</table>

In return of the total of 417 posts the automotive brands made, the users interacted with 452,475 likes, 7,936 comments, and 12,556 shares in average. Moreover, the view number information which is only kept on video posts is 2,964,935 for the total 64 videos. Hyundai has the highest number of likes per post with 10,537 likes, and Fiat has the highest number of comments per post with 178 comments, the highest number of shares per post with 378 shares, and the highest number of views per post with 758,839 views. Fiat holds a figure of views approximately more than three times higher than the sector average in number of views, an a figure of shares more than two times higher than the average in shares (Table 6 and Table 7).
Table 7  User Interactions in Return of the Posts Made on Automobile Sector Brand Pages

<table>
<thead>
<tr>
<th>Sector Average</th>
<th>Per Post</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Likes</td>
<td>Comments</td>
</tr>
<tr>
<td>Average</td>
<td>5,412</td>
<td>104</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>3,771</td>
<td>103</td>
</tr>
<tr>
<td>Renault</td>
<td>6,029</td>
<td>98</td>
</tr>
<tr>
<td>Ford</td>
<td>1,544</td>
<td>58</td>
</tr>
<tr>
<td>Fiat</td>
<td>5,179</td>
<td>178</td>
</tr>
<tr>
<td>Hyundai</td>
<td>10,537</td>
<td>85</td>
</tr>
</tbody>
</table>

* Only video posts have the view data.

4.2 Media Type

In the media type dimension, 22% of the total 417 posts the brands designed has high interactivity, while 78% has low figures of interactivity; 15% has high vividness, while 6% has medium and 78% has low vividness. 32% of all the posts of Volkswagen which, has the highest values in interactivity in vividness, has high interactivity, and 26% have high vividness. The lowest figures belong to Ford with 87% ratio of low interactivity and the same ratio of low vividness (Table 8).

In the content dimension, 23% of the posts in the sector are entertaining, 67% is informative, and 11% is rewarding. Renault has the highest ratio of entertaining posts with 40%, Hyundai has the highest ratio of informative posts with 91%, and Ford has then highest ratio of rewarding posts with 18% (Table 8).
Table 8. Media Types and Contents of Automobile Brand Page Posts

<table>
<thead>
<tr>
<th>Sector</th>
<th>Volkswagen</th>
<th>Renault</th>
<th>Ford</th>
<th>Fiat</th>
<th>Hyundai</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pcs</td>
<td>%</td>
<td>Pcs</td>
<td>%</td>
<td>Pcs</td>
</tr>
<tr>
<td><strong>Media Type-Interactivity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High (Video-Link-Event)</td>
<td>91</td>
<td>0.22</td>
<td>31</td>
<td>0.32</td>
<td>17</td>
</tr>
<tr>
<td>Low (Photograph-Status)</td>
<td>326</td>
<td>0.78</td>
<td>66</td>
<td>0.68</td>
<td>31</td>
</tr>
<tr>
<td><strong>Media Type-Vividness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High (Video)</td>
<td>64</td>
<td>0.15</td>
<td>25</td>
<td>0.26</td>
<td>11</td>
</tr>
<tr>
<td>Medium (Link-Event)</td>
<td>27</td>
<td>0.06</td>
<td>6</td>
<td>0.06</td>
<td>6</td>
</tr>
<tr>
<td>Low (Photograph)</td>
<td>326</td>
<td>0.78</td>
<td>66</td>
<td>0.68</td>
<td>31</td>
</tr>
<tr>
<td>None (Status)</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entertaining</td>
<td>95</td>
<td>0.23</td>
<td>34</td>
<td>0.35</td>
<td>19</td>
</tr>
<tr>
<td>Informative</td>
<td>278</td>
<td>0.67</td>
<td>48</td>
<td>0.49</td>
<td>26</td>
</tr>
<tr>
<td>Rewarding</td>
<td>44</td>
<td>0.11</td>
<td>15</td>
<td>0.15</td>
<td>3</td>
</tr>
</tbody>
</table>

In case the media type of the posts is photographs the average number of likes per post is 6,121 and the average number of comments per post is 98; in case the post is a video, the highest number of shares per post is 278, thus indicating the highest figure (Table 9).
Table 9 Averages of Likes, Comments, and Shares per Post of Automobile Brand Page Post Media Types

<table>
<thead>
<tr>
<th></th>
<th>Likes</th>
<th>Comments</th>
<th>Shares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photograph</td>
<td>6,121</td>
<td>98</td>
<td>129</td>
</tr>
<tr>
<td>Link, Event</td>
<td>4,458</td>
<td>69</td>
<td>108</td>
</tr>
<tr>
<td>Video</td>
<td>2,292</td>
<td>92</td>
<td>278</td>
</tr>
</tbody>
</table>

4.3 Time
On a weekly period, the most posts were made by the automobile brands on Wednesdays with 14 posts, and the least posts on Sundays with 6,4 posts. While the companies generally make posts everyday on their Facebook brand pages, only Fiat does not have any posts on Sundays (Table10).

The posts are most frequently made in the sector between 09:00–10:00 and 16:00–18:00. The time period of posting is 07:00–21:00. (Figure 2).

Table 10 Posting Times of Automotive Sector Brand Page Posts (Days of the Week)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector Average</td>
<td>12.6</td>
<td>13.4</td>
<td>14</td>
<td>12.8</td>
<td>13.8</td>
<td>10.4</td>
<td>6.4</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>15</td>
<td>17</td>
<td>16</td>
<td>17</td>
<td>16</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Renault</td>
<td>6</td>
<td>9</td>
<td>7</td>
<td>10</td>
<td>7</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Ford</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>Fiat</td>
<td>12</td>
<td>7</td>
<td>11</td>
<td>8</td>
<td>12</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Hyundai</td>
<td>15</td>
<td>18</td>
<td>19</td>
<td>14</td>
<td>18</td>
<td>15</td>
<td>12</td>
</tr>
</tbody>
</table>
68% of the user comments on the posts of automobile brands are posted within the first 24 hours, and 32% takes place following the first 24 hours. In the total user comments, the most comments in the first 24 hours were received by Volkswagen with the ratio of 84%, and the least were received by Renault with 29% (Table 11).

Brand posts receive the most comments on Fridays (Figure 3). Comments are usually posted between 16:00 and 22:00 during the day (Figure 4).

Table 11  User Comment Frequency on the Automobile Brand Page Posts within 24 Hours

<table>
<thead>
<tr>
<th></th>
<th>Comments within 24 Hours (%)</th>
<th>Comments after 24 hours (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector Average</td>
<td>0.68</td>
<td>0.32</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>0.84</td>
<td>0.16</td>
</tr>
<tr>
<td>Renault</td>
<td>0.29</td>
<td>0.71</td>
</tr>
<tr>
<td>Ford</td>
<td>0.78</td>
<td>0.22</td>
</tr>
<tr>
<td>Fiat</td>
<td>0.48</td>
<td>0.52</td>
</tr>
<tr>
<td>Hyundai</td>
<td>0.83</td>
<td>0.17</td>
</tr>
</tbody>
</table>
Table 12 presents the results of negative binominal regression analysis regarding media types that are formed on the pages of automobile sector, video (high interactivity and high vividness), event and link (high interactivity and medium vividness), photographs (low interactivity and low vividness), content (entertaining, informative, rewarding), time dimension (workdays, weekend, work end (17:00, 18:00,19:00), other hours), in terms of user transitions (likes, comments, and share). The effects of other variables tried to be identified by based on media type (photograph), content (entertaining), time dimension (weekend and other hours).
Table 12  Analysis of Automotive Sector Brand Page Posts upon Consumer Engagement Dimensions

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Likes</th>
<th></th>
<th></th>
<th></th>
<th>Comments</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Shares</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Exp (B)</td>
<td>Std. Error</td>
<td>Sig.</td>
<td>B</td>
<td>Exp (B)</td>
<td>Std. Error</td>
<td>Sig.</td>
<td>B</td>
<td>Exp (B)</td>
<td>Std. Error</td>
<td>Sig.</td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>7.529</td>
<td>1860.996</td>
<td>.2187</td>
<td>.000</td>
<td>3.433</td>
<td>30.964</td>
<td>.1955</td>
<td>.000</td>
<td>3.410</td>
<td>30.261</td>
<td>.2206</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Video (I=Y, C=Y)</td>
<td>-.778</td>
<td>.459</td>
<td>.1813</td>
<td>.000</td>
<td>-.175</td>
<td>.839</td>
<td>.1522</td>
<td>.249</td>
<td>.746</td>
<td>2.108</td>
<td>.1665</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Link, Event (I=Y, C=O)</td>
<td>-.359</td>
<td>.699</td>
<td>.2482</td>
<td>.148</td>
<td>-.447</td>
<td>.640</td>
<td>.2210</td>
<td>.043</td>
<td>-.265</td>
<td>.767</td>
<td>.2346</td>
<td>.259</td>
<td></td>
</tr>
<tr>
<td>Photograph (I=D, C=D)</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>Entertainment</td>
<td>1.016</td>
<td>2.762</td>
<td>.2344</td>
<td>.000</td>
<td>1.057</td>
<td>2.877</td>
<td>.2034</td>
<td>.000</td>
<td>1.321</td>
<td>3.748</td>
<td>.2218</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Information</td>
<td>1.379</td>
<td>3.970</td>
<td>.2071</td>
<td>.000</td>
<td>1.038</td>
<td>2.823</td>
<td>.1845</td>
<td>.000</td>
<td>1.328</td>
<td>3.772</td>
<td>.1993</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Remuneration</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>Workdays</td>
<td>.081</td>
<td>1.084</td>
<td>.1558</td>
<td>.604</td>
<td>.315</td>
<td>1.370</td>
<td>.1365</td>
<td>.021</td>
<td>.371</td>
<td>1.449</td>
<td>.1448</td>
<td>.010</td>
<td></td>
</tr>
<tr>
<td>Weekend (Saturday, Sunday)</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>Work-end (17:00, 18:00,19:00)</td>
<td>-.575</td>
<td>.563</td>
<td>.1452</td>
<td>.000</td>
<td>-.225</td>
<td>.798</td>
<td>.1227</td>
<td>.067</td>
<td>-.406</td>
<td>.666</td>
<td>.1345</td>
<td>.003</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>Deviance/df</td>
<td>1.241</td>
<td>1.190</td>
<td>1.215</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative binomial</td>
<td>1.509</td>
<td>.0886</td>
<td>1.185</td>
<td>.0729</td>
<td>1.335</td>
<td>.0821</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.4 Media Type

Automobile brands used media types of video (high interactivity, high vividness), link, event (high interactivity, medium vividness), and photograph (high interactivity, low vividness) on Facebook. During the research, “event” was only used once by one brand, and “status” was never used.

While media type was found to be significant on likes ($\chi^2(2, N=417) = 19.723 \ p < 0.0001$) and shares ($\chi^2(2, N=417) = 23.229 \ p < 0.0001$), no significance was found in commenting action.

Compared to the photograph type which has low interactivity and low vividness, video ($B= -0.778 \ \text{Exp}(B)= -0.459 \ p < 0.0001$) which has high interactivity and high vividness, was found to reduce the dependent variable of “likes” by 54% and to be negatively significant. Event and link which have high interactivity and medium vividness are found to be insignificant. Video ($B= 0.746 \ \text{Exp}(B)= 2.108 \ p < 0.0001$) %110.8 was found to increase the sharing and to be positively significant, while link and event were found to be insignificant. The reason why there is a positive significance between photograph and video on “likes” and a negative one on “sharing” is that in case of interactivity a similar difference should be observed on “event” or “link”, yet the level in between is insignificant. Moving from this, it is seen that the reasoning factor that makes the difference between photograph and video is vividness. In this context, H1a and H1b hypotheses were rejected for likes and comments, and H1a was accepted for sharing while H1b was rejected.

4.5 Content

In the model designated to examine the post content, content was found to be a significant determinant on likes ($\chi^2(2, N=417) = 45.629 \ p < 0.0001$) comments ($\chi^2(2, N=417) = 33.461 \ p < 0.0001$) and shares ($\chi^2(2, N=417) = 45.900 \ p < 0.0001$).

Compared to rewarding content, entertaining content increases likes ($B= 1.016 \ \text{Exp}(B)= 2.762 \ p < 0.0001$) by 176.2%, increases comments ($B= 1.057 \ \text{Exp}(B)= 2.877, \ p < 0.0001$) by 187.7%, and increases shares ($B= 1.321 \ \text{Exp}(B)= 3.748 \ p < 0.0001$) by 274.8%, thus displaying a significant role. Compared to rewarding content, informative content increases likes ($B= 1.379 \ \text{Exp}(B)= 3.97 \ p < 0.0001$) by 297%, increases...
Online Consumers Engagement on Facebook Brand Pages

comments (B = 1.038 Exp(B) = 2.823 p < 0.0001) by 182.3% and increases sharing (B = 1.328 Exp (B) = 3.772 p < 0.0001) by 277.2%, thus displaying a positive significant role. Entertaining content, while achieving a higher value on comments than informative content, remained lower on likes and shares. In this context, H2a were rejected for likes and shares. While the informative content were expected to have higher values than remunerative content and lower values than entertaining content in the H2b hypothesis, informative content was higher than the both. Consequently, H2b, H2a, and H2b Hypotheses were accepted.

4.6 Posting Time
In the designated model, the posting day was found to be a significant determinant on comments \( (2, N=417) = 5.326 \ p < 0.05 \) and shares \( (2, N=417) = 6.569 \ p < 0.05 \), and insignificant on likes. Compared to holidays, the workdays were found to increase comments \( (B = 1.016 \ \text{Exp}(B) = 1.37 \ p < 0.0001) \) by 37%, and shares \( (B = 1.016 \ \text{Exp}(B) = 1.449 \ p < 0.0001) \) by 44.9%, thus displaying a positive significant effect. As a result, H3a hypothesis were rejected for likes, but accepted for comments and shares.

In the designated model, the posting hour was found to be a significant determinant on likes \( (1, N=417) = 15.699 \ p < 0.0001 \) and on sharing \( (1, N=417) = 9.115 \ p < 0.01 \). Compared to the other hours, the 3 hours following the work-end (17:00, 18:00, 19:00) decreases likes \( (B = -0.575 \ \text{Exp}(B) = 0.563 \ p < 0.0001) \) by 43.7%, decreases shares \( (B = -0.406 \ \text{Exp}(B) = 0.666 \ p < 0.01) \) by 33.4%, thus displaying a negative significant effect. In this context, H3b hypothesis was rejected for likes, comments, and shares.

Table 13 Hypothesis Results

<table>
<thead>
<tr>
<th></th>
<th>H1a</th>
<th>H1b</th>
<th>H2a</th>
<th>H2b</th>
<th>H3a</th>
<th>H3b</th>
</tr>
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<tbody>
<tr>
<td>Likes</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>A</td>
<td>R</td>
<td>R</td>
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<tr>
<td>Comments</td>
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<td>A</td>
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<td>Shares</td>
<td>A</td>
<td>R</td>
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R = Rejected
A = Accepted
5 DISCUSSION
This study is a pioneer research that examines the effect of media type, content and creating time of posts on the automobile industries Facebook brand pages in Turkey on OCE. For four months detailed data have been collected about the brand pages and user interactions of five brands which constitute 55% of the total personal automobile sales in the year 2015 in Turkey. Data in hand show a general view of the sector due to OCE.

Depending on the sector and the country, different results are seen when posts created by brand pages are studied about the effect on OCE (Jayasingh & Venkatesh, 2015; Cvijikj & Michahelles, 2013; Golshani, 2015). In various countries when most favorite brand pages are studied, e.g. USA-Wall Mart(Retail), UK-Amazon.Co.Uk(e-Commerce), Brasil-Coca Cola(Beverage) (Anon., 2016) - though different in fields—a great effect of sector on OCE is also observed.

There are differences in users’ social network usage and OCE motivations (socialization, entertainment, reward, identity seek and information search) among sectors (Park, et al., 2009, p. 729; Heinonen, 2011, p. 359; André, 2015, p. 13). For example, users’ reasons may vary to follow luxury brands or fast food companies (Kim, et al., 2015, p. 22). In this study, too, the expectancy is met for different results compared to the study done before (Food, (Cvijikj and Michahelles, 2013)) on OCE in different sector.

Main reason for differences in OCE motivations, the research has been carried out with product groups in different sectors (favorable and easy). Contrary to easy products, in favorable products, the need for information in order to receive recommendations for use in post purchase, and comparing price, quality and features has been eliminated in pre purchase. The differences between product groups directly effect content type which brings forward entertainment in food and informative in car.

In line with the findings of this study, a study carried out in Korea in automobile sector indicates that there is not a significant difference among brands (BMW, Mercedes-Benz, Renault-Samsung, Ford, Hyundai etc.). Rather than mentioning entertaining issues on their pages, these companies highlight brand awareness and brand name (Choi, 2012). Users welcome these posts which contain ads of new products, features
of existing products and the advantages they provide on the pages of companies in automobile sector and OCE is the most effective content that positively affects these posts.

Media types in brand pages mostly consist of photographs which have low vividness and low interactivity (Cvijikj and Michahelles, 2013; Golshani, 2015; Jayasingh and Venkatesh, 2015; De Vries, et al., 2012). Photographs are preferred because photographs are less costly and can be loaded within low internet speed and quota and its effect on OCE have made photographs more preferable.

The difference between sector and countries does not effect media type as photography but it can be a determinant factor on media types regarding OCE. In a study carried out on food, accessories, clothes, cosmetics, and mobile devices sector indicate that videos received more likes (De Vries, et al., 2012) whereas in another study conducted in India report that photographs received more likes in nineteen different sectors including automobile sector (Jayasingh and Venkatesh, 2015). This study supports the findings of earlier research in that photographs are the most widely used media type. However, different from previous research, it is found out that photographs have a positive effect on commenting as well as liking.

When the results are analyzed regarding the day the posts are created, it has been seen that the posts which are created in weekdays have a more significant effect on OCE compared to posts which are created at the weekends (Cvijikj and Michahelles, 2013; Golshani, 2015; De Vries, et al., 2012). Different from earlier studies, although the effect of weekdays is evident, there is not a significant positive effect of end of business day (17:00, 18:00, and 19:00) on OCE. The on hand access to social networks by mobile technologies has made it difficult to specify the time which increases OCE.

Here in this study, a survey is done on automobile sector brand page posts’ features in Turkey to determine their effect on OCE. The results of this study corroborate with previous literature regarding the effect of brand page posts in terms of media type, post creating time and the content on OCE. Besides, the results show that photograph at media type, informative at content and workdays at time dimension stand out.
6 CONCLUSION

It is possible to say that there is a positive relation between the highness of sales figures of brands and the highness of number of the likes, comments, and shares they have on their Facebook pages. For example, Fiat automobiles, liked by approximately a million of people on their Facebook Turkey page, have the fourth highest sales figures. On the other hand, their Facebook account has very much higher figures in comments, shares, and views than the others. Their view per post data is nearly ten times higher than the brand with the leading sales figures. It is observed that, during the period when the research data was collected, Fiat was advertising for a new product and applied the integrated marketing communication practices with success in a manner to include traditional media as well. In this scope, it is understood that brands should increase their OCE on their Facebook brand pages and use the other media instruments and traditional media altogether, in other words, they should manage the integrated marketing practices well.

In this study, hypotheses that were created in order to measure the effects of media type, content, and posting time of the posts prepared by the automotive sector brand pages on the likes, comments, and shares of the users were tested. In consequence of the hypothesis tests conducted; it was seen that the low level interactivity has no significant effect on likes and shares, and vividness is only significant on shares. Thereby, it is understood that it would be more suitable for brands to make photograph posts when they wish to get likes, and video posts when they wish to be shared. It is also seen that media type is effective on comments on a post.

It is seen that in the post design, entertaining and informative contents are more effective than rewarding contents. Entertaining and informative contents get more likes, comments, and shares compared to the rewarding contents. And when the informative and entertaining contents are compared, informative contents are clicked by the users significantly more times than the entertaining contents, in respect of likes. While the posts made on workdays receive more comments and shares, the same does not apply for the likes. The posts made during the 3 hours following the work-end (17:00, 18:00, and 19:00) were observed to be negative in respects of likes, comments, and shares.
Businesses that want to increase OCE should prefer photographs and videos as media types, and informative and entertaining contents as content types, and workdays as the posting time. Although both photographs and videos increase OCE, photographs draw attention per post from more people than videos in respect of likes, comments, and shares. For this reason businesses should prefer photographs more often.

It is seen that informative contents which, have a positive effect on OCE, are preferred by the businesses more. However, the fact that there are advertisement blocker software such as AdBlocker today, the fact that more similar software may emerge in the future may cause problems in the word-of-mouth communication endeavors made in Facebook brand pages. In order to overcome this, the posts should be prepared in the framework of socializing and having a good time, the main motivations of social media users. Entertaining and informative contents should be presented together. From another point of view, informative messages should be place within entertaining contents. Most of the user comments happen in the first 24 hours, even though workday posts have a positive effect in increasing OCE, requires companies to designate more specific posting hours during the day by organizing the user data.

This study was conducted by examining the data of the Facebook brand pages of five automobile brands which has the 55% of the market share in the total automobile sales in Turkey in 2015, in a way to include a four month period. The primary limitation of the study was that the data of the whole sector could not be obtained and the study was conducted on a single social network. Moreover, the fact that we could not access the hours of likes and shares, because Facebook Graph API would not allow it, prevented further analyses from being conducted.

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KEY TERMS
Social Media
Social Network
Facebook
Brand Pages
Consumer Engagement
Media Type
Content
Posting Time
Online Consumer Engagement
Automobile Industry

QUESTIONS FOR FURTHER STUDY
1. Is there any difference among different cultures in terms of online consumer engagement?
2. How can be measured the online consumer engagement in other social media sites (Twitter, YouTube etc.)?
3. Is there any difference in “like”, “comment” and “share” the effect on online consumer engagement? How can be measured?
4. What are the possible effects of Facebook emoji on online consumer engagement?

EXERCISES
Suppose you are a social media manager in a company. Your manager wants you to design a Facebook brand page for a new product. What do you care about to make a successful design?

As a social media user what kind of content are you interested in? Compare the different Facebook brand pages. What are the attractive characteristics of the popular contents for you?

What are the possible consequences of any failure managing the social media site? Consider that in terms of relationship marketing perspective.
FURTHER READING


LEARNING OBJECTIVES
The objectives of this chapter are to provide detailed information on Electronic Medical Records (EMRs), to propose an implementation success model of EMRs and to give some summary information of Healthcare Industry in a developing country context. Once you have mastered the materials in this chapter, you will be able to:

- Understand the key technology, managerial and social concepts behind the Electronic Medical Records
- Explain key benefits and advantages of EMRs
- Identify Critical Success Factors in EMR implementation
- Understand and realize the key constructs of successful EMR implementation process
- Observe major unique characteristics of Information and Communication Technology (ICT) implementation in a developing country context

CHAPTER OUTLINE
This chapter aims to provide detailed information on Electronic Medical Records (EMRs), their implementation process and major success factors behind the implementation process. In addition, you will learn the major advantages and benefits of EMRs, besides their limitations and disadvantages. You will also learn the main underlying information systems platform of Turkish Healthcare, called saglik.net as an example of Electronic Health Care Management System from a developing...
country perspective. The chapter also proposes an EMR implementation success model and the chapter also will discuss in detail the constructs made up of EMR success model. So you will learn which critical factors play an important role in achieving successful implementation outputs for an EMR system.

**KEYWORDS**
Electronic medical Records (EMRs), EMR Success Model, Critical Success Factors of healthcare ICTs implementations, Saglik.Net

1 INTRODUCTION
Since 20th century, small and large organizations all have felt the need to enhance their productivity and efficiency. Not surprisingly, much of the efficiency and productivity increases have come from new Information and Communication technology (ICT) investments. Today, ICTs are clearly necessary for firm’s survival and success. Although ICTs have usually enhanced the organizational performance, factors actually lead to success in implementation process of ICTs and these factors are not very well understood and outlined by the researchers (Larsen, 2001). Healthcare industry is not different. Healthcare providing organizations are furiously trying to reduce continuously increasing healthcare costs and enhance customer service. Healthcare expenditures in all over the world are continuously increasing. Healthcare spending is expected to exceed 4 trillion USD by 2017 in USA by comprising 20 per cent of US GDP (Wurster et al, 2009). Therefore, healthcare executives are trying to limit these ever increasing costs. ICTs are the major tool and help for healthcare providers’ management team to reduce costs and enhance customer service. Worldwide hospital administrators perceive ICTs as a strategic force needs to be utilized (Caccia-Bava et al, 2006). Hospital managers also seem to understand the important impact of ICTs on organizational performance. Healthcare service delivery is one of the most significant challenges that healthcare organizations face today. Healthcare organizations must continuously find ways to improve efficiency while drawing down costs and remaining financially viable (Thambusamy and Palvia, 2011). In addition, hospital managers should see ICT as a strategic weapon.

Although healthcare managers understand the positive impacts of ICTs on hospitals performance, successful implementation of ICTs still
depends on user acceptance and actual usage of the systems (DeLone and McLean, 2003). Healthcare managers mostly perceive ICTs as a necessary evil, rather than a strategic necessity (Caccia-Bava et al., 2006). Electronic medical Records (EMRs) are newly emerging ICTs that have become widely implemented, adopted and used in healthcare settings.

Health Information technologies (HITs) are one of the most expensive capital investments of any health organization (Cohn et al., 2009). Implementation and adoption of HITs are complex process and requires especially physician's and other health personnel's support. HITs are composed of Electronic Medical Records (EMRs), computerized physician order entry and decision support systems all of which integrating and improving access to health related patient data (Cohn et al., 2009). HITs can improve patient and physician relationships, decision making abilities for clinicians, provide efficient access to medical and patient information and can reduced healthcare providing costs and errors.

Scholars’ and practitioners have long argued that ICTs are fundamental to firm’s performance, growth and survival, yet they still failed to present the linkages between ICTs and financial performance. Effective and efficient use of ICTs is key factor to differentiate successful firms from unsuccessful ones. ICTs can be seen as an organizational capability. Organizations need to do much more than investing in ICTs and try to create organization wide ICT capabilities. Organizations also need to know or predict the outcomes of Information Systems (IS) to reduce failure rates of their IS investments (Szajna and Scamell, 1993). So early on evaluation of IS development stages can provide extraordinary benefits to IS implementation efforts.

Services sector now account more than third of developed economies GDP. Now a “service world” is emerging in which organizations, people, technology and regulations form new mode of service delivery (Brynson et al., 2004). Changing customer requirements and advancements in ICTs have moved industries from product base to service based economy (Thambusamy and Palvia, 2011). This can create new opportunities for organization to enable service based industries. Successful implementation of ICTs in healthcare industry can create new business models and service innovation for healthcare organizations.
Healthcare service delivery can be enhanced by increased transparency and process driven methods.

There is too much opportunity to innovate in services and provide customized services with lower costs and in a fast manner with the help of ICTs. ICT adoption can enhance competitive advantage of organizations and provides a lot of opportunities especially in services industry (Spohrer and Riecken, 2006). Yet, healthcare industry is the one industry that lags the implementation of health information systems behind. Healthcare organizations have to decrease soaring costs and enhance customer healthcare delivery satisfaction. New and successful implementations of ICTs in healthcare can create new and innovative business models and facilitate new healthcare service delivery methods. Increased data availability and transparency can enable to use data driven methods in healthcare delivery and managerial decision making processes (Thambusamy and Palvia, 2011).

Implementation of EMRs has been getting widespread in developing countries, yet there are limited studies on implementation success of EMR in developing country context (Tilahun and Fritz, 2015). Knowing important antecedents of EMR success factors in the implementation process can have significant effects on reducing already high costs of EMR implementations. Hence this study could be among the first studies proposing EMR success factors in the implementation process of EMR in Turkish settings.

This study is aimed to examine EMRs, ICT implementations in healthcare settings, an example of a major Turkish healthcare ICT infrastructure and after an extensive literature review offer a process model of EMR Implementation success. At this point, this research is not focused on validating or testing the proposed EMR success model, yet it can offer a valuable framework for further empirical studies.

2 ELECTRONIC MEDICAL RECORDS

Electronic Medical records (EMRs), Electronic patient Records (EPRs), Computer Based Patient Records (CPRs) and Electronic Health Records (EHRs) are all used interchangeably to refer to a collection of electronically maintained information related with individuals’ health status and healthcare (Zhang and Zhang, 2016). While EMR, EPR and CPR refer to records implemented at a single or several healthcare
institutions, EHR contains records of all personal health information of an individual during his or her lifetime, entered or accepted and accessible by healthcare organizations on multiple sites. EHR is integrated health record system that ultimately all healthcare system is trying to achieve.

Implementing modern health information technologies in developing countries can create many advantages such as modernizing healthcare in those low resource areas, saving lives of largely poor population and eliminating burden of poor handling medical records by considering severe lack of health professionals and basic facilities (Tilahun and Fritz, 2015). Getting timely and proper patient information can facilitate speedy and proper human and financial resources allocation that could help hospital management utilize already scarce resources more properly.

Governments all around the world have started to allocate significant resources to promote EMRs acceptance and adoption by hospitals and healthcare professionals. Successful adoption of EMRs is important not only increasing service quality and patient safety, but also reducing continuously increasing healthcare costs. All ICT investments in healthcare settings shall be organized around critical business and patient care processes of hospitals. Previous ICT research could not found a robust and consistent relationship between ICT investments and organizational paradox that is called Information technology Paradox (Khatri, 2015). Existing ICT capabilities play an important role in achieving significant benefits from ICT investments. Since ICT investments are quite complex in nature, organizations with greater ICT capabilities can reap more benefits from their ICT investments than organizations without ICT capabilities (Khatri, 2015).

Duplication of laboratory tests and prescriptions are not a rare occurrence even in developed countries. For example in Taiwan, number of doctors consulting a patient is about 15 in every year in average (Li et al., 2015). Creation of medical Health Records and exchange systems of health records could be a solution to this problem.

Electronic Medical Records (EMRs) are largely expected to reduce medical errors and enhance service quality in Healthcare Industry. EMRs also expected to increase personnel productivity in healthcare settings. Yet, these technologies are widely resisted by same professionals.
expected to benefit from the widespread usage of these systems (Bhattacherjee and Hikmet, 2007). Healthcare personnel usually perceive new healthcare information systems as a great distraction from their regular duties. This resistance from healthcare professionals not only complicates our understanding of information technology adoption, but also undermines potential benefits of Health Information Systems (HIS). One of the significant ways to enhance success of HITs in healthcare settings is to better understand the HIT implementation process and this study is aimed to propose an implementation success model of a HIT as a process model.

If managers address adequately the change in power and change in organizational balance, the resistance of new technology will prevail. EMR can be seen as a strategic resource, increasing organizational competitive advantage by reducing operational costs and enhancing organizational efficiency. A sample EMR screen is provided below in Figure 1.

Figure 1  Sample EMR Screen

![Sample EMR Screen](https://doi.org/10.5771/9783828868427)

Source: Wager et al., 2009
What needs to be placed in EMR screen is not a simple question (Wagner et al., 2009). In addition measuring EMR adoption is difficult since it does not occur at the same time at different organizations and measuring adoption levels is quite difficult.

2.1 Advantages of EMRs

Implementation of EMRs is believed to improve efficiency, access and quality of healthcare services (Zhang and Zhang, 2016). EMRs are one of the central elements that play significant role in transformation healthcare services and they form the central piece in forming the healthcare information systems architecture. EMR systems can significantly increase accuracy of healthcare and patient information recorded in health records, can support clinical decision making and improve accessibility of patients’ healthcare information (Zhang and Zhang, 2016).

Other benefits of EMRs can include reduced waiting times for patients, reduced medication order errors and simplified reports generation process. Because of limited healthcare budgets in developing countries, open source or free EMR software are largely used in healthcare facilities (Zhang and Zhang, 2016).

EMRs can facilitate healthcare professionals’ access to patient data and can significantly improve quality of the data available at healthcare organizations. EMRs can also improve drastically efficiency of healthcare processes through following standard procedures and reduced medical errors. Ultimately EMRs is expected to enhance healthcare and well-being of patients.

2.2 Saglik.Net

This section of the chapter an important transformation project of Turkish Healthcare, Saglik.Net is discussed. The WHO defines e-health as using information and communication technologies for health providing (Li et al., 2015). E-health can include treating patients, conducting research, educating health professionals, tracking diseases and monitoring public health. Saglik.Net is one of the fundamental elements of transformation process of Turkish healthcare and it is one of the significant elements of Turkish healthcare reforms. It is one of the backbones and fundamental elements of Turkish e-health initiatives. Electronic medical records
are consisting of a critical component of e-health initiatives of Turkish healthcare. This project includes all citizens and with broadband access in whole Turkey, health professionals can access all historical and current health information and records of each patient and the system is also supporting e-medicine applications that is the foundations of electronic medical records. The system also keeps track of work force, chattels and real estates as well administrative and financial information of all healthcare providers in the country. The main targets of Saglik.net is listed below:

- To achieve standardization in health information
- To form data analysis and decision support systems
- To increase data sharing speed among e-health participants
- To create electronic personal medical records
- To create resource savings and enhance productivity
- To coordinate variety of e-health endeavors
- To provide support scientific research
- To get e-health concept adopted throughout the country

Saglik.Net is an information system platform that is integrated, secure, fast and extendable to collect all health institutions electronically created healthcare data, to produce valuable information to all stakeholders of Turkish Healthcare and ultimately to achieve performance and quality increase in service delivery in first, second and third stage of healthcare providers.

Saglik.Net can help to define problems before hand in healthcare industry, to offer solutions to the possible problems and to form work lists and investment plans in healthcare industry and to collect data to help variety of research studies in the healthcare. The basic characteristics of Saglik.Net framework is listed below:

- Based on Internet technology and can transfer data from first, second and third stage healthcare providers’ independently acquired health information systems
- Decision support system that could effectively participate in decision making process, assess sickness type and its severeness and healthcare expenses with the access to demographic

1 http://www.e-saglik.gov.tr/belge/1-33811/sagliknet-hakkinda.html
information and seemingly transfer of the data to Ministry of Health
- Reporting system that can help to satisfy International Organizations different demands on Turkish Healthcare statistics
- Infrastructure that could provide international information data exchange according laws and regulations
- Providing abilities and capacities to Turkish citizens to access their health information and manage them
- Providing early warning systems in healthcare to access to healthcare information

The layout of administrative login interface and web site of Saglik.Net is provided below in Figure 2.

Figure 2 The Administrative Login Interface of Saglik.Net

Saglik.Net is administered by Turkish Ministry of health and their logo and link can be seen on the right hand side of the page. User name and password are also located in the middle of the webpage.
3. CRITICAL SUCCESS FACTORS IN EMR IMPLEMENTATIONS

The critical success factors of EMR implementations are not clear in the literature (Standing and Cripps, 2015). Although many studies have considered successful factors in adoption process, they do not consider generally context of adoption. Implementation and adoption e-health technologies vary among countries. The barriers in front of the adoption are documented, but for many countries and healthcare systems, addressing these barriers is still a major problem (Cripps and Standing, 2011). Some of the major barriers are the wide range of stakeholders with different objectives, the risk environment due to the critical nature of patient healthcare and healthcare professionals’ feeling of being overwhelmed due to enormity of the information and communication (ICT) transformation task.

Since healthcare industry has its own unique and characteristic challenges and barriers, critical success factors have become important. Critical Success Factors premise that if they are adequately or completely considered, then system as a whole has greatly improved chances of adoption and implementation success. Critical Success Factors is simply defined as techniques for improving chances of systems success. The success could be information systems success, general project success or organizational success. Success factor is defined by Daniel (1961).

Critical Success Factors has been extensively used in Management information Systems literature. Without strategic and detailed perspective, main intention based technology acceptance models such as Technology Acceptance Model and Unified Theory of Acceptance and Use of Technology—UTAUT by Venkatesh et al. (2003) has outlined key factors in technology acceptance and the critical success factors in adoption process.

Table 1 in the following page presents Critical Success Factors from e-health studies literature. The Table 1 is adopted from the recent paper of Standing and Cripps (2015) and outlines seven scholarly papers in Management Information Systems literature. The Critical Success Factors in e-health implementation success has been classified in seven categories as type of system, stakeholder involvement, vision and strategy alignment, communication and reporting, process implementation, consideration of ICT infrastructure and other factors.
Literature suggests three attributes on the level of innovation for the success of EMR systems that are data entry hardware quality, existing flexibility of user interfaces and presence of decision support tools (Struik et al., 2014). If EMR systems are easy to use and compatible with the existing working environment at the organizations, users are more willing to adopt and use these systems.

The involvement of users and stakeholders is generally viewed one of the most important factors in EMR implementation success. Since work practices are largely changed when new ICT is introduced, it is required to have major players to involve into development and implementation process (Deutsch et al., 2010). Since healthcare information systems have broad range of interest groups, the collaboration and partnership with clinicians and other stakeholders play a crucial role in implementation success (Kaye et al., 2010). In addition, stakeholder management skills need to be observed as a valuable skill set (Vitacca et al., 2009) and communication protocols can be utmost necessary in building strong and good user/stakeholder communication (Amatayakul, 2000).

Top management support is essential in EMR adoption by physicians (Chen and Hsiao, 2012). Existence of mission and vision in the process of EMR adoption are also very important. Leadership and commitment of the top management seem to be essential as well. Since EMR systems have privacy implications, careful planning and management of the migration and transfer to the new healthcare IS present utmost importance (Amatayakul, 2000). Project management skills can create successful and unsuccessful implementation projects of EMRs (Deutsch et al., 2010). Hence the most common Critical Success Factors presented in these seven articles are (Standing and Cripps, 2015);

- Stakeholder/user involvement
- Having a vision/plan for the role of ICTs
- Alignment with organizational mission, goals and objectives
- A process for implementation that includes an integration and migration path from the old to new systems
- Communication with users including the reporting of benefits

Resource Based View (RBV) and IT (Information Technology) Business Value Model can provide valuable underlying framework for EMR implementation success process. This school of thought can also provide how ITs could be associated with competitive advantage in the
Table 1  Critical Success Factors in e-health Acceptance and Adoption Process

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<tr>
<td>Type of system</td>
<td>Computer based patient records</td>
<td>Core competencies to implement e-health and telemedicine</td>
<td>General ICT in health sector</td>
</tr>
<tr>
<td>User/ stakeholder involvement</td>
<td>End-user involvement; knowledge requirement assessments</td>
<td>Patient-centered care; partnering with patients</td>
<td>Multidisciplinary team</td>
</tr>
<tr>
<td>Vision and strategy, and strategic alignment</td>
<td>Systems support organizational vision; do systems enable business goals of organization?</td>
<td>Public health perspective</td>
<td>Innovative leadership: vision; commitment; practical needs</td>
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<tr>
<td>Communication and reporting</td>
<td>Communicate value of the systems to users</td>
<td></td>
<td>Communicate clear benefits</td>
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<tr>
<td>Communication of benefits and funding Process for implementation, migration, integration and training</td>
<td>Need for an integration and migration plan for the system</td>
<td></td>
<td>Process for implementation; financial incentives for clinicians; collaborative processes; training for clinicians</td>
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<tr>
<td>Plan for ICT infrastructure</td>
<td>Longer-term systems infrastructure</td>
<td>ICT plan</td>
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<tr>
<td>Others</td>
<td>Evaluate the systems to manage benefits delivery</td>
<td>Quality improvement: evaluation and organizational learning</td>
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<tr>
<td>General ICT in health sector</td>
<td>Hospital information systems</td>
<td>Electronic health records adoption</td>
<td>Hospital information systems by physicians</td>
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<td>Buy-in from stakeholders</td>
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<td>Project team competency</td>
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<td>Health policy-related goals and implementation strategy</td>
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<td>Top management support</td>
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<td>Communication and reporting</td>
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<td>Training</td>
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<td>Acceptance and change management; project management</td>
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<td></td>
<td></td>
<td></td>
<td>Ease of systems use</td>
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<tr>
<td>Dealing with unpleasant events; amount of resistance</td>
<td>Highly committed developers and their understanding of the organization</td>
<td>Legal requirements related to data protection</td>
<td>Systems quality</td>
</tr>
</tbody>
</table>
IT context (Melville et al., 2004). Figure 3 below outlines impacts of the major characteristics and resources of an organization on organizational performance as proposed in Business Value model from Melville et al. (2004).

Figure 3  IT Business Value Model

Researchers has applied RBV framework in order to theoretically analyze the competitive advantage results of information Technology and to assess the relationships between IT and other firm resources in order to enhance firm performance and ultimately to create competitive advantage.
4 The Proposed Electronic medical Record Implementation Success Model

Below is the proposed electronic medical Records (EMR) implementation success model. The model is designed as a process model, where two proposed characteristics and capabilities of the organization, Electronic Medical Records Heath Information Systems leads to organizational performance construct.

The research model is largely based originally on DeLone and McLean’s (2003) seminal work on ICT implementation success literature review. In addition more recent paper by Thambusamby and Palvia (2011) has been used to some extent to form the constructs and process flow of the offered model in this research. The research model of EMR success factors has been presented in Figure 4 below.

Figure 4 The Proposed EMR Implementation Success Model

The factors/constructs that made up of the model are discussed below.

4.1 Capabilities

Capabilities are related with capacity and capabilities of implemented EMR system, organization and ICTs.

4.1.1 EMR Capabilities

*Complexity* is the degree of difficulty in understanding and using the ICT. Complexity is opposite to ease of use that is systems relative perceived feelings of free of mental and physical effort (Davis, 1989). Technical
complexity of EMR: technical complexity is the EMRs suitability with the existing systems namely hardware and software. If ICT related systems are easier to integrate, there is a greater chance of realizing full organizational benefits (Tornatzky and Klein, 1982). Moreover, the more compatible EMR with existing software, the more satisfied users are. Rogers (1983) defined complexity of the systems among one of the five factors influencing end users to adopt new technologies. Complexity is the degree of innovation is difficult to use. Complexity is the degree of difficulty in innovation’s understanding and implementation (Rogers, 1983). Users tend to reject new innovations that are too complex technically, requires advanced user skills, produce inconsistent reports and need extensive expert support (Sharma and Yetton, 2007). Complex technologies can create knowledge barriers reducing possibility of user adoption and acceptance. Complexity is among the key barriers to technology adoption (Lin, 2007). Hence, complexity of ICTs has adverse effects on implementation success.

Compatibility is defined as the degree of innovation being consistent with existing organizational values, beliefs, needs and experiences (Rogers, 1983). Compatibility is the degree of innovation’s consistency with existing organizational values, beliefs and experiences. Relative Advantage, complexity and compatibility are mentioned as most significant factors playing important role in ICT based innovations diffusion (Lin, 2007). Lin (2007) argued that greater compatibility of innovation with organizations processes can create familiarity and enhance the acceptance of innovation. In EMR case, compatibility is the degree of new EMR system to be able to exchange data with other existing systems in the healthcare organization. Relative advantage, complexity and compatibility are the most frequently used in the literature factors for ICT based innovation diffusion (Lin, 2007).

Relative Advantage is the degree that innovation brings benefits to the organization. Organizations prefer and adopt innovations that bring organizational benefits rather than maintaining status quo. Relative advantage is a multidimensional construct capturing the benefits of a system such as lower costs, savings in time and effort and decrease in comfort (Choudhury and Karahanna, 2008). Relative advantage is the degree of innovation to bring benefits more from its precursor (Lin, 2007). Relative advantage can be in terms of increased efficiency,
effectiveness, economic benefits and enhanced status. Relative advantage is related how much EMR brings benefits to the healthcare providers, healthcare personnel and administrative bodies. If healthcare providers, doctors and administrative bodies perceived sufficient benefits from EMR adoption, they would most likely to use it.

4.1.2 Organizational Capabilities

*Top management Support*: Full commitment from senior executives is a must for successful implementation of ICTs. Top management should send a clear signal to various departments in an organization that the project is important (Bradford and Florin, 2003). System orientation requires various organizational departments have clear view of organizational objectives and understand how they can help in development of ICTs (Lin, 2007). Organization having and emphasizing managerial support can achieve better and greater extent of ICT diffusion. Management should ensure firm’s employees understand and become involved in EMS implementation process.

*Training*: Since EMR packages can be quite complex, user training is necessary for successful implementation. Training can enhance organizational performance measures and also make better allocation of organizational resources while increasing user satisfaction (Bradford and Florin, 2003). End user training is a critical for the successful implementation of ICTs (Sharma and Yetton, 2007). Hence many ICT investments would be organized with expensive formal training programs. Training programs can enable users to acquire knowledge in three main domains as application knowledge regarding the knowledge on commands and tools of the new application implemented, business context knowledge regarding learning how to perform business tasks successfully and collaborative task knowledge related with how other colleagues use the application for their tasks (Sharma and Yetton, 2007).

4.2 Quality

This construct refers to the quality of services provided EMR software and system and also healthcare providers.

*Information Quality* is the output quality of an Information System. Information Quality has five distinct dimensions as completeness, ease of understanding, personalization, relevance and security. In terms of
EMR, the information quality characteristics can be relevance, accuracy, timeliness, content, format, completeness and understandability. Both system quality and information quality regarded as important indicators in systems implementation success (DeLone and McLean, 2003). EMR systems with high level of information quality shall provide quality information and outputs to healthcare workers.

*Service Quality* is the overall user satisfaction and assessment of an IS. Service quality is related with reliability, assurance and responsiveness of the service provided by the system. Service Quality concept is originated from Parasuraman et al’s (1998) SERVQAUL instrument. DeLone and McLean (2003) suggested five dimensions of service quality that are tangibility, reliability, responsiveness, assurance and empathy. EMR systems service quality could include system’s visual appealing, interactivity, empathy, being trustworthy and responsive to users’ requests. Services are different from physical goods and most intangible. Services are processes and satisfaction depends on confirmation of expectations (Grover et al, 1996). Traditionally the effectiveness of Information Systems has been measured by the products it has produced mostly rather than the service it has served. Hence, if we do not incorporate service quality in the process of measuring Information Systems efficiency, the measurement will be inaccurate.

*System Quality* is the desired characteristics of an Information System. System Quality has six dimensions as stated by DeLone and McLean (2003): adaptability, availability, reliability, response time and usability. In terms of EMR system’s quality, the dimensions can be ease of use, ease of navigation, consistency of page layouts and visual appeal.

### 4.3 Performance

Performance is related with organizational, individual performance, satisfaction of end users and final expected real system use.

*Organizational Performance* is overall performance of healthcare provider. The existing research on how ICTs can affect organizational performance is somewhat uncertain and debatable (Melville et al, 2004). Literature seems to show divergence in how to conceptualize key constructs and existing relationships between ICTs and organizational performance. In general literature seems to indicate the positive relationship between ICT investment and firm performance (Melville
et al, 2004). The value created by ICTs can be shared with the company, trading partners and customers. Organizational performance is related with how efficiently organizational resources are utilized. It includes usage of ICT resources and management of other organizational resources such as people, capital and equipment.

*Individual Performance* is the performance of individual user while performing their works and duties. It is the degree of EMR system to enhance physicians and other health employees’ performance. Increased performance can result in increased satisfaction of healthcare professionals as well as patients.

*Satisfaction* is related with end users’ satisfaction of the system. End users are people who directly interact with computers. End user computer satisfaction is one of the measures of end user computer success (Doll and Torkzadeh, 1988). End user satisfaction is the degree of satisfaction of end users from their direct interactions with a specific Information System. End user computer satisfaction is the direct attitude of users interacting with a specific computer application (Doll and Torkzadeh, 1988). End user satisfaction has been found to have a direct and positive effect on intention to use, yet it has no causal relationship with direct use (Chen and Cheng, 2009).

*End User Satisfaction (EUS):* User satisfaction is an important topic for IS researchers (Whitten, 2004–2005). End User Satisfaction is a critical factor in success of ICT implementation (Au et al, 2008). Today it is widely acknowledged that ICT implementation failure is most due to psychological and organizational factors rather than technological issues. Many IS projects fail because of lack of commitment from users and top management. People should be willing to use and utilize new ICTs to get the full benefit from these systems. After 1990s new variables such as equity, training method, task uncertainty and task complexity have been added as factors to explain End User Computer Satisfaction construct (Au et al, 2008). In order to better understand the roots of satisfaction, we need to pay close attention to motivation. Landy and Becker (1987) mentioned three theories of motivation that are expectancy theory, needs theory and equity theory. By integrating these three well known organizational theories, we can have better understanding of EUS. Based on the Equity Theory (Pritchard, 1969), individual feel satisfied or dissatisfied if his or her inputs are greater than the benefits received from
the transaction. In IS context, the inputs and benefits for IS end users are usually too narrowly or too unclearly defined. Need satisfaction has found to be positively correlated with satisfaction (Oliver, 1995). Usually ignored by IS developers and managers, social and self-development needs could potentially cause significance resistance from end users in ICT implementation process.

System use is related with the active, real and physical use of the system by end users. The better capabilities of EMR system, Organization and general ICTs can lead to improved system, service and information quality that in turn enhances organizational, individual performance and satisfaction, resulting more and more system usage. Earlier DeLone and McLean (2003) model has laid a good and fundamental characteristics of information System leading satisfaction and usage. The authors also included system quality factor that is fundamentally related to user attitudes and perceptions of the system.

5 Organizational learning and System Adoption

Organizational learning is another important factor to consider in ICT implementation success. Learning is quite related with past experience and past experience with ICTs can enhance greatly future implementations success (Robey et al, 2000). Therefore, experience with technology in earlier days of organization can have positive and profound effects on implementation success of new information technologies. In addition, information technologies can provide remote access to organizational memory of organizational members by fostering communication and discourse.

The following critical success factors in EMR are created based on Nah et al (2003)’s study of ERP success factors based on CEOs.

1. Appropriate business settings existence: If the healthcare organization has complex legacy systems in use. Then the implementation would require much more technological and organizational changes. The EMR implementation should reduce the complexity created by organization and existing legacy systems.

2. Appropriate business plans and visions existence: Creating effective business plan and vision, creating and sharing project mission
and goals and justifying investment in EMR are necessary for successful EMR implementation. Since EMR implementation can exceed time frame of typical organizational project, clear and concise business plan and vision are required. The project mission should be related to business needs and be clearly stated.

3. **Fostering change management culture and program**: Recognizing the need for change, enterprise wide culture and structure management and user education and training, user support and organizational involvement, commitment to change are required for successful EMR implementation. If the change required for EMR implementation process, there should be more and clear top management support. At the same time, people, organization and culture of the organizations shall be changed. Formal training programs for users to better explain how EMR systems would affect their job are required.

4. **Communication**: Targeted and effective communication among stakeholders, project communication and user input are necessary for successful EMR implementation. Every organizational level should know their expectations and responsibilities through implementation process. Communication among stakeholders is critical success factor in EMR implementation success.

5. **EMR teamwork and composition**: Best people on team, cross functional teams, full time team members, empowered decision makers are needed for successful EMR implementation. EMR requires collaboration and cooperation of administrative and medical employees of a healthcare organization. Especially physicians and nurses support is a must. Organizational, medical and technical knowledge is necessary for successful implementation. ERP team should have experts from all organizational areas and best people need to be employed in the teams.

6. **Monitoring and evaluating the performance**: Track milestones and targets, performance tied compensation, analysis of user feedback. Feedback from users that is medical staff in addition to feedback from patients also needs to be integrated in project performance evaluation and progress criteria.
7. **Project champion**: Existence of project champion, high level executive support to champion and project sponsor commitment are required. Since EMR implementation requires organizational commitment and determination, project champion is needed in such implementation efforts. This champion needs to be high level manager of the organization and be able to set goals and legitimize the change.

8. **Project management**: Assigning responsibility, clearly establishing project scope, controlling project scope, evaluating any proposed change, defining project milestones, setting realistic milestones and dates, enforcing project timeliness, and coordinating project activities across all affected parties are necessary for implementation project success. Since most IS project are evaluated based on the extent to meet their time and budget constraints, project management activities are really important. Hence, the EMR implementation project needs to be also managed based on best project management practices. Budget, implementation time, total effort, people’s commitment and project schedules can easily cause project failures, if not predicted and managed properly.

9. **Top management support**: Approval and support from top management, top management publicly and explicitly identified project as top priority, allocate resources makes the success chances of implementation process better. Top management support is one of the main necessities of ICT projects implementation success. The EMR project has to be approved and supported by top management. For successful EMR implementation, top management should involve and clearly show their support and willingness to allocate valuable resources to the other organizational members.

As listed above, the potential factors in successful implementation of ICTs include top management support, extensive user designer interaction, compatibility of task characteristics, innovation characteristics such as relative advantage, complexity and compatibility, commitment to change and implementation efforts and sufficient project planning and definition (Lee and Kim, 2007). Process of innovation adoption can be influenced...
by three factors that are external environment, technological context and organizational context (Lee and Kim, 2007). Market uncertainty, competitive intensity and government support are among the factors related with external environment. Compatibility and complexity are the main factors as technological context and formalization and centralization of the organization are the major factors of organizational context. Obtaining top management support is major requirement for successful implementation along with having a project champion who would educate parties and promote the project is also a necessity.

6 CONCLUSION
Effective implementation of new technologies is necessary to solve organizations productivity problems. Successful implementation of ICTS depends on our better understanding of user attitudes and behaviors and efficient implementation process of such technologies. Technology alone is not sufficient successful implementation of ICTs and transformation of successful human resources management practices are also necessary (Connor et al, 1990). The process success model of EMR implementation can be a valuable guideline for healthcare provider institutions managers for a better grasp of important factors in the success of EMR systems implementation.

Other ICT implementation factors including IS expertise, IS security, IS infrastructure, Project champion can also be the independent variables of future research. Another good predictor of EMR implementation success would be the external vendor or consultant support. Significant and important role of vendors and consultants are mentioned as a significant factor in EMR implementation success (Tsai et al, 2011).

Yet EMR is coming not without disadvantages. Ineffective communication has been mentioned as the one of the most important reasons to cause preventable medical errors (Taylor et al., 2014). EMRs can help to increase communication and connectivity in healthcare (Institute of Medicine, 2001). EMRs can address the existing problem of communication among nurses and physicians in hospitals. However Taylor et al., 2014) found that EMRS in fact could decrease frequency of face to face communication between physicians and nurses. Moreover, the authors argued that quality of communication even got worsened after EMR implementation. Face to face communication has some
favorable features such as observing and reacting verbal and non-verbal cues compared with electronically mediated communication. Research in the literature (Beuscart-Zephir et al., 2005; Niazkhani et al., 2009) indicated that specific EMR implementation of Computerized Physician Order Enter (CPOE) can replace face to face (Synchronous) with electronically mediated (Asynchronous) communication. EMRs can also have other disadvantages mainly although access is possible to medical records, EMRs cannot review the information in the records. Furthermore, EMRs may impose additional administrative tasks on already heavily burden healthcare administration. Privacy and security issues, hardware problems, system problems, time required to learn how to operate the system and decreased patient-physician interaction could be other disadvantages of EMR systems (Zhang and Zhang, 2016).

References


Zhang, X. Y. and Zhang, P. (2016), “Recent Perspectives of Electronic Medical Record System”, Experimental and Therapeutic Medicine, (11: ), 2083—2085
KEY TERMS
Electronic Medical Records
Advantages and disadvantages
Critical success factors
EMR implementation Model
Turkish Healthcare Systems
Organizational learning systems
Healthcare systems adoption
Organizational performance

QUESTIONS FOR FURTHER STUDY
1. What is the definition of Electronic medical Records?
2. What are the main advantages of utilizing EMRs?
3. What is Saglik.Net? What are unique features and significance of Saglik.Net?
4. What are the critical success factors in EMR implementation process?
5. How various capabilities of an organization or EMR influence the performance of organization and individual users?
6. What is a learning organization and how being a learning organization influence the adoption process of EMRs

EXERCISES
How Information and Communication Technologies have affected our lives and specifically healthcare industry? Please discuss.

How Information and Communication Technologies utilization and implementation as well as usage differ in developing countries comparing developed nations? Please discuss.

If you are a manager in a healthcare organization, how could you assess the success or failures of your EMR implementation endeavor? Please discuss.
Visit a hospital and investigate their patient admission, treatment and prescription system. Prepare a report on how useful this system in improving hospital's performance?

**FURTHER READING**


INNOVATIVE DEVELOPMENTS AND ECONOMIC GROWTH: 
THE CASE OF TURKEY

LEARNING OBJECTIVES
Once you have mastered the materials in this chapter you will be able to:
- Understand the relations between endogenous technological variables and economic growth.
- Identify basic technology investments and their returns to aggregate production.
- Clarify the key functional relationships between progress in technology and booming economies.
- Recognize human capital input in R&D activities.
- Analyze the cooperation of human capital and physical capital in the R&D sector.

CHAPTER OUTLINE
The study of the relationship between technology and economic growth has been the main focus in modern economic literature for over the last century. The Schumpeterian approach was used to explain the economic growth of the developed countries. New technical developments led to cost cuts and price deductions and this innovative competition led to the quick economic growth of countries which encouraged this innovation and development. This chapter analyzes the effects of innovation and technology on economic growth in Turkey over the past three decades. Significant and direct relations have been found between the innovation data and economic growth. We begin with a specific analysis of each series. The series’ graphs are drawn and their descriptive statistics are...
calculated. The relation between innovation and economic growth is tested by Ordinary Least Square Method and Engel Granger test. The test results of the specified period show a positive influence of technological progress on economic growth in Turkey both in the short-run and long-run.

**KEYWORDS**
Development, Economic Growth, Innovation, R&D, Technological Progress, Time Series Analysis

1 INTRODUCTION
The Turkish economy has always been open to international markets and has always attempted to fully integrate into the global economy both during the Ottoman Empire and Turkish Republic periods. However, the Turkish economy has also been fragile because of political instability and insufficient law systems stemming from poor infrastructure investments. The Turkish economy had a very small growth rate between 1923 and 1939. From World War II up until 1950, the economic growth rate fluctuated frequently.

The first multi-party election was in 1950. The liberal party gained power and continued good relations with the allies. Good relations with USA brought new investment opportunities to Turkey. The foreign trade increased immediately. New financial aids and credits were received. The infrastructure investments led to the construction of roads, dams and refineries. Education became more accredited with the west.

The army revolted in 1960 and the first election took place in 1962. The 1960s also witnessed the cold war years and the founding of The State Planned Office. The central government focused on planned investments. Its duty was to plan government investments and be a guide for private sector investments.

2 LITERATURE REVIEW
Schumpeter was the first modern economist who paid attention to technological progress. He focused on the relation between technological development and economic growth. Today’s R&D growth models are derived from Schumpeter’s theory (Aghion et al. 2014). The backbone of Schumpeterian growth model depends on innovations. New
innovations are monitored by entrepreneurs who as a result, redirect their investments. Thereby, new technology eliminate old technology (Aghion et al. 2015). The new technology allow producers to produce their yields at lower cost (Romer 1987). A much higher amount can be produced with the same input by using new technology (Romer 1990a). Today new innovations are mainly counted by patent applications. A new piece of literature called, “The Patent Race” describes this competition in detail (Aghion & Howitt 1992). Competition also adds efficiency to the market. Investors aim to invest their funds in fields which have high returns. Consequently, this encourages entrepreneurs to invest in high productive and high profitable sectors (Borsch-supan & Romer 1998). Productivity increases could be observed continuously in the long-run (P. M. Romer 1986a). In addition, technology research also increases consumers’ welfare (Loo & Soete 1999). The results of each research bring about new types of products. Product differentiation allows consumers to have more opportunities. When Technological progress is combined with human capital, the productivity growth can reach much higher levels (Lucas 1988). There is a debate in literature whether technology is exogenous or endogenous (Mankiw et al. 1995). However, most economists lean towards the theory that it is endogenous. Modern technological growth models attempt to prove that technology is a variable which comes from within the model.

Economists began studying technology functions in the late 1970s (Romer 2001). These growth functions were thence named new endogenous growth models. The economists aimed to explain countries’ developments by using these new growth models. Technology was accepted as a public possession at the beginning (Romer 1990b). However, the following years saw the monopolization of new technology. New inventions supply monopolistic rent to their owner. These new inventions were protected by patent laws. However not every new invention was kept by patent law. A new term called “intellectual property rights” was now being used in economic literature. Technology and legal systems began to be discussed in the economic system (Romer 1990c). Technology specification found a new platform to be defined again. Economists found that each type of technology had a different kind of influence on economic growth (P. Romer 1986). The following researches focused on the technology change rate. It was observed
that the countries with a high technology change rate had a higher
growth rate than other countries. Thus countries with fast developing
technologically had comparative advantages over others (P. M. Romer
1986b). The New technology definition brought about a new aspect in
growth theory. The dynamic growth model was built using this new
technological definition (Romer 1994). Technology became equivalent
to change in today’s world. Globalization and technological progress
were now aligned together (Romer 2010).

The Turkish economy became more integrated into the western
economic system after 1970. Close relations with USA and Western
Europe provided an accelerated force for economic growth. However,
despite the economic growth, the law system and infrastructure was
not sufficient enough to sustain the growth. In general, the coalition
governments were usually in power and this lead to a lack of cooperation
between the different political factions which lead to instability.

The liberal party won the general election in 1983 and stayed in
power for the next 10 years. This period was a breath of fresh air for
the economy where telecommunication systems, high ways, integrated
electric networks and new hydraulic energy power dams were set up.

Furthermore, the new acts were designed for the market. The
Turkish currency became convertible and the new capital market act
was accepted. New regulations were put forward for foreign investments
and the new tariff system was checked every week by the cabinet. The Turkish economy grew rapidly in this period and the Foreign trade increased.

However, the economy slowed down in the 1990s. The political instability had a very bad effect on the economy. The coalition governments had big budget deficits. Public debts were financed by bonds. The interest rate in the market increased dramatically. The investments rate slowed down. Export and income growth slowed down as well. The exports could not compensate for the imports any more. There were two big devaluations in 1994 and 1999.

Fig. 2 GDP per Capita (in Current USD)

![GDP per Capita Chart](https://doi.org/10.5771/9783828868427)

A majority government won the election in 2002. The new government had good relations with the European Union. The law, trade, education, transportation systems were up to standards which are a requirement for the EU.

The national technology policy began in 2002 and the technology of national defense was renewed. Private investors were now permitted to invest in defense technology. The National Research and Development law was also accepted in parliament and this led to significant financial support for the R&D investors. In addition, the transportation system policy was renewed with plans for new railways and highways and constructions (international airports and bridges) was on the way.
3 ECONOMIC GROWTH OF THE TURKISH ECONOMY

3.1 National Income Growth

The economic growth of modern Turkey can be divided into four periods. The first period is between 1970 and 1983. The 70s were the years when the private sector struggled to join the global economy. The Turkish lira was a pegged currency and the transaction of foreign exchange was not permitted in the domestic market. This led to a strong foreign currency demand in the market. The Turkish lira was losing sudden values. GDP was 18.825 billion USD in 1970. It reached 67.457 billion USD in 1980. GDP had declined to 11 % in 1971 and 17 % in 1980. The economy had grown more than 3 times in this decade in Current USD term.

Fig. 3 GDP (Current USD, million USD)

![GDP Graph]

Source: Turkish Statistical Institute

Table 1 Descriptive Statistics of GDP (million USD)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Maximum</th>
<th>Std. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>251351.0</td>
<td>823044.0</td>
<td>257832.2</td>
</tr>
<tr>
<td>Median</td>
<td>149195.0</td>
<td>16847.00</td>
<td>1.163792</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>257832.2</td>
<td>Skewness</td>
<td>2.880826</td>
</tr>
<tr>
<td>Observations</td>
<td>45</td>
<td>Kurtosis</td>
<td></td>
</tr>
</tbody>
</table>
The army took over the administration in 1980. The next election was in 1983. The economy experienced a 17% loss in 1980. The growth rate rose 4% in 1981 but the following three years saw a decline in growth rates once again. The growth rates were -10% in 1982, -5% in 1983 and -3% in 1984. The growth rates did not become negative until 1991.

The GDP was 67.457 billion USD in 1980 and reached 149.145 billion USD in 1990. The growth of the economy doubled during this decade.

The 90s witnessed the coalition years in Turkey. Any political party could not be elected for majority government between 1992 and 2002. Coalition governments usually had public finance problems. Big budget deficits brought high interest rates. Investments slowed down. The Central Bank was known as the finance authority during this period. People used foreign exchange in the domestic market because of high inflation. Three substantial crisis occurred in this decade. One in 1994, one in 1999 and the last one in 2001. The economy shrank to 26% in 1994, 9% in 1999 and 17% in 2001. All three of the crisis were caused by internal dynamics. There were no global negative influences on the economy. The GDP was 149.156 million USD in 1991. This value could only reach 196.736 USD in 2001. Overall, the economy had grown 30% in this decade.

The last period is 2002 and onwards. There has only been one crisis since which occurred in the year 2009. It was a global crisis. The Turkish economy reduced 17%. The GDP was 230.494 billion USD in 2002. At
end of 2014, the GDP was 800 billion USD. The economy had grown three and a half times during this decade.

3.2 GDP per Capita Growth

The GDP per capita growth trend has followed the same growth rate of the GDP. Equal fluctuations in each period of GDP can be seen in GDP per capita growth path.

Fig. 5 GDP per Capita (Current USD)

GDP per capita grew 3 times between 1970 and 1980. GDP per capita was 533 USD in 1970. It reached 1518 USD in 1980. Between 1980 and 1990 GDP per capita growth rate was 75%. GDP per Capita was 2655 USD in 1990.

GDP per capital had only increased 16% between 1990 and 2001. GDP per capita was only 3019 USD in 2001. Per capita income grew more than 3 times in the last decade and it reached 10,404 USD in 2014.
3.3 Manufacturing Sector Growth

The manufacturing sector had a slow positive growth rate until 1983. However, from 1983 onwards, the growth rate of the manufacture sector began to increase. The high growth rate slowed down again in the 90s because of coalition governments. This lead to big fluctuations evident in this period. The next break point was the year 2002. The growth rate in the sector had risen more than ever before. But the global crises effected the sector in 2009 negatively. The sector is still struggling to recover. There has been a positive growth rate since 2010 but not as high as before.
The new liberal government encouraged exporters by the new value added tax return law in 1983. The foreign trade tariffs were designed to attract exporters. Raw material and intermediate input imports became easier. Foreign exchange currencies were now permitted to be transacted in the market. The price of currencies was determined in support of the exporters.

Fig. 8  Manufactures Export and Imports

The share of manufacture exports in merchandise exports has increased in the past decades. This increase is perceived as a diminished increase. 26.8 % of exports was sourced from the manufacture sector. The share increased to 67.8 % in 1990 and 84.5 % in 2004. The share increase stopped in 2004 and shares have begun to decrease slightly since with absolute values. The share reduced to 77.73% in 2013.

The structure of manufacture import share in merchandise imports is similar to that of manufacture exports, however the increase halted in 1998 with 75.6 %. The rate reduced to 57.8 in 2013. The trend shows that the structure of Turkish imports changed dramatically after 1998. Turkey is not importing manufactured goods as it previously did.

4  INNOVATIVE DEVELOPMENT

Most of the Turkish Technological statistics have been recorded since 1990. As such, there is a lack of secure data sources before 1990. This section is planned to shed some light on these limited resources.
4.1 Gross Domestic Expenditure on R&D

The ratio of each country’s Gross Domestic Expenditure (GERD) on R&D to GDP is usually accepted as one of the prime indicators. Turkey’s GERD as a percentage of GDP was 0.24 % in 1990. This ratio reached 0.48 % in the year 2000. GERD as a percentage of GDP was recorded as 0.95 %.

Figure 9 gives information of world developed countries’ R&D expenditures. Turkey’s expenditure ratio is less than other countries on the graph. But there is an increasing trend for Turkey. It has almost doubled over the last ten years. The GERD of Germany as a percentage of GDP was 2.94 %, France was 2.23 %, and UK was 1.63 % in 2013.

![GERD as Percentage of GDP](https://doi.org/10.5771/9783828868427)

Source: OECD Main Science and Technology Indicators

Turkey’s GERD was about 780 million USD in 1990. It increased four times in the following 10 years and reached 2.8 billion USD in the year 2000. At the end of 2013, GERD was 13.3 billion USD in Turkey.

The world highest R&D expenditure was recorded in USA in 2013. It was about half a trillion USD. Germany’s R&D expenditure was over 100 billion USD, France’s was 55 billion USD and UK’s was 40 billion USD in 2013.
Financial source of R&D expenditure has changed. The percentage of central or federal governments in each country’s R&D expenditures have declined over the last three decades. The government’s share was nearly 50% in developed countries. It was 53.4% in France, 47.8% in USA, 46.37% in UK and 41.79% in Germany at the beginning of the 80s.

Central governments’ financing shares decreased radically in the following years. The developed countries central government R&D expenditures reduced to around 40% in 90s and 30% after the year 2000. The ratios of central government finance on R&D in France was 34.97%, 30.97% in US, 26.99% in UK and 29.21% in Germany in 2013.

Turkey’s public share of R&D expenditure was 71.42% in 1990. It decreased to 50.6% in 2000 and was recorded as 26.55% in 2013.
Percentage of R&D financed by private industry have increased over the whole world, both in developed and developing countries. Industry contribution on R&D expenditure in many countries was below the %50 in 1980. It was 40.92 % in France, 42.05 % in UK and 49.42 % in US. Germany was a bit higher with a ratio of 56.85%.

By the time Germany’s Industry contribution on R&D expenditure reached to 66.07 % in 2013, the ratio was announced as 59.13 % in
US, 55.38% in France and 46.55 % in UK. More than half of R&D expenditure is financed by industry in most of the developed countries. Turkey’s industry ratio in R&D expenditure was 27.44 % in 1990. It increased to 42.92 % in 2000 and 48.87 % in 2013.

The ratio of total Turkish researchers to total Turkish employment was 0.067 percent in 1990 while it was 0.6 % in USA and in Germany, 0.5 % in France and the UK. The structure of trend changed for Turkey in 2002. It became steeper while other countries remained the same. The ratio of researchers to employment was 0.34 percent for Turkey in 2013. The developed countries’ ratios were around 0.8–0.9 percent in 2013.

89 thousand Turkish researchers were employed in the market at the end of 2013. This statistic recorded 1.3 million in USA, 360 thousand in Germany, 265 thousand in France and 259 thousand in UK.
The total number of universities was 184 in 2013. It was 28 in 1985 and 73 in 2000. The increase in the number of universities had a positive effect on new job opportunities for researchers in universities. The new and increasing positions in universities had a direct influence on published scientific papers. The number of total published scientific paper was 326 in 1985 and was doubled in 1990 to 750. This increased to 3,484 in 2000 and 8,328 in 2013.

208.6 thousand Scientific papers were published from USA in 2011. Germany and UK had an annual of 46 thousand scientific papers and France’s papers were recorded as 31.6 thousand.
The total resident patent applications were 134 in 1980. It had a horizontal trend until 2000 when the total number of annual application reached 277. After 2000 the annual application growth rate increased. 2,268 applications were completed in 2008 and 4,861 applications in 2014.

Non-resident applications increased until 1995. Total non-resident applications were 1,520 in 1995. However, this reduced to 713 in 1996 and rose again to 3,156 in 2000. This increase was followed by a decline until 2003. The total non-resident applications were 685 in 2003.
following years were increment years. Total non-resident patent applications were 7,514 in 2014.

The total number of Turkish firms’ trademark applications to Turkish Patent Office were 2,143 in 1980. 1980s were very poor years for direct resident applications. The total number of Turkish brands or trademarks applications began to increase in the 90s. The total non-resident application was 3,200 in 1990. The year 2000 and the following years marked a speed up for registration. Total non-resident applications reached 8,344 in 2000 and 14,746 in 2013. The crisis of 1994, 1999, 2000, and 2009 could be easily noticed in resident applications time path. 93,341 trademark applications were completed by resident mark owners to National Patent Office in 2013.

4.2 Technology Transfer

Turkey’s computer and electronic exports was 4.6 million US Dollar in 1981. The new regulations which aimed at integrating the national economy with the global economy gave its fruit in the following ten years. Turkish computer and electronic exports rose to 302.6 million US Dollars in 1990. Technology imports increased more than three times in 2000 and it was recorded 1.074 billion US Dollar. This figure rose to 2.66 billion US Dollars in 2013.

Fig. 17 Export of Computer, Electronic and Optical Industry (Current USD in million)
Turkey entered the arena of international technology competition late. Turkish technology exports statistics in US Dollar is quite low but exports growth rate is comparatively higher than developed countries. In 2013, technology exports for USA was 194.6 billion US Dollars, Germany was 114 billion US Dollars, France was 37.1 billion US Dollars and UK was 35.8 billion Dollars.

Computer and electronic devices imports provided technology transfers. Turkish computer and electronic imports was 177.7 million US Dollars in 1980. Technology transfer increased with the new liberalization in the economy. Computer and electronic imports increased ten time reaching 1.66 billion US Dollars in 1990. It was 6.4 billion US Dollars in 2000 and 14.5 US Dollars in 2013. Turkish technology imports were almost quarter of France, UK, half of Germany and one tenth of USA in 2013.

There has been another significant development in Turkey which is that of the aerospace industry. Turkey’s aerospace export was zero in the 1980s. Turkish aerospace exports was 0.54 million in 1990. Turkish Aerospace Industry (TAI) was founded in Ankara. Turkey started to produce fighter jets in Ankara with NATO allies. USA is still a strategic partner in the aerospace industry. The industry developed rapidly and industry exports increased to 582.1 million US Dollars in 2000. In 2013 the aerospace industry export was 931.7 million US Dollars. The Turkish
aerospace industry exports is however behind that of the exports of
developed countries.

Fig. 19  Total Exports of Aerospace Industry (Current USD in million)

US aerospace exports was 116.8 billion US Dollars, France was 67.1
billion US Dollar, Germany was 51 billion US Dollars and the UK was
37.7 billion US Dollars in 2013.

Fig. 20  Total Imports of Aerospace Industry (Current USD in million)

Turkish aerospace imports is comparatively behind developed countries.
Turkish aerospace imports was 23 million US Dollars in 1980, it rose to
298.3 million US Dollars in 1990. The year 2000 statistics is 1.1 billion US Dollars and it reached 2.6 billion US Dollars in 2013. UK imports was 30 billion US Dollars and USA was 46 billion US Dollars in 2013, while Germany’s import was 35.5 billion US Dollars and France’s imports was 38 billion US Dollars.

5 THE ANALYSIS AND RESULTS
In this section structural determinants of technological development in Turkey is analyzed. Each variable given in the previous section is classified into three classes. The linear relations between these classes is then tested by ordinary least square methods.

5.1 Variables
The data set is classified into two classes as Economic Growth variables and Innovation sector variables.

Table 2 Classification of the Variables

<table>
<thead>
<tr>
<th>Classes</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Growth</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td></td>
<td>Gross Domestic Product per Capita</td>
</tr>
<tr>
<td>Innovation Sector</td>
<td>Gross Domestic Expenditure on R&amp;D</td>
</tr>
<tr>
<td></td>
<td>Total Researchers</td>
</tr>
<tr>
<td></td>
<td>Scientific and Technical Journal Articles</td>
</tr>
<tr>
<td></td>
<td>Patent Applications</td>
</tr>
<tr>
<td></td>
<td>Trade Mark Applications</td>
</tr>
<tr>
<td></td>
<td>Export of Computer, Electronic and Optical Industry</td>
</tr>
<tr>
<td></td>
<td>Export of Aerospace Industry</td>
</tr>
<tr>
<td></td>
<td>Import of Computer, Electronic and Optical Industry</td>
</tr>
<tr>
<td></td>
<td>Import of Aerospace Industry</td>
</tr>
</tbody>
</table>
The series were supplied from different sources. The Gross Domestic Product and GDP per Capita series were sourced from the Turkish Statistic Institute. The series are published in current US Dollars.

Gross Domestic Expenditure on R&D and Total Researchers statistics were sourced from OECD Main Science and Technology Indicator Data Base. Gross Domestic Expenditure on R&D is published in current US Dollar.

Total Number of Scientific and Technical Journal Articles, Total Patent Applications, Total Trade Mark Applications were taken from World Bank Development Indicator Data Base.

Total Export - Import of Computer, Electronic and Optical Industry and Total Export-Import of Aerospace Industry series were sourced from OECD Main Science and Technology Indicator Data Base. Both series are in term of current US Dollar.

All series are run in natural logarithm form for the analysis. The natural logarithm series of all variables, their descriptive statistics and their distributions are given below;
Fig. 21  Time Series of All Variables in Natural Logarithm
Fig. 22  Distribution of All Variables in Natural Logarithm
Table 3 Descriptive Statistics of All Variables

<table>
<thead>
<tr>
<th></th>
<th>ln GDP</th>
<th>ln GDP per Capita</th>
<th>ln Gross Domestic Expenditure on R&amp;D</th>
<th>ln Total Number of Researchers</th>
<th>ln Scientific and Technical Journal Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>26.05537</td>
<td>8.937847</td>
<td>21.89885</td>
<td>10.46464</td>
<td>7.776103</td>
</tr>
<tr>
<td>Maximum</td>
<td>27.43628</td>
<td>9.829518</td>
<td>23.31216</td>
<td>11.63487</td>
<td>9.064239</td>
</tr>
<tr>
<td>Minimum</td>
<td>24.79473</td>
<td>7.964170</td>
<td>20.47334</td>
<td>9.543306</td>
<td>5.786897</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.874079</td>
<td>0.530554</td>
<td>0.864888</td>
<td>0.676366</td>
<td>1.114551</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.163210</td>
<td>0.012317</td>
<td>0.186852</td>
<td>0.302294</td>
<td>-0.336192</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>1.787467</td>
<td>2.062856</td>
<td>1.805908</td>
<td>1.736984</td>
<td>1.725978</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>2.233780</td>
<td>1.245031</td>
<td>1.565510</td>
<td>1.960737</td>
<td>2.334637</td>
</tr>
<tr>
<td>Probability</td>
<td>0.327296</td>
<td>0.536593</td>
<td>0.457145</td>
<td>0.375173</td>
<td>0.311200</td>
</tr>
<tr>
<td>Sum</td>
<td>885.8824</td>
<td>303.8868</td>
<td>525.5725</td>
<td>251.1515</td>
<td>209.9548</td>
</tr>
<tr>
<td>Sum Sq. Dev.</td>
<td>25.21247</td>
<td>9.289094</td>
<td>17.20470</td>
<td>10.52185</td>
<td>32.29780</td>
</tr>
<tr>
<td>Observations</td>
<td>34</td>
<td>34</td>
<td>24</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>In Patent Applications</td>
<td>In Trade Mark Applications</td>
<td>In Export of Computer, Electronic and Optical Industry</td>
<td>In Import of Computer, Electronic and Optical Industry</td>
<td>In Export of Aerospace Industry</td>
</tr>
<tr>
<td>-----------------------------------------------------------------</td>
<td>------------------------</td>
<td>----------------------------</td>
<td>------------------------------------------------------</td>
<td>------------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Minimum</td>
<td>4.836282</td>
<td>7.593878</td>
<td>15.23379</td>
<td>18.99594</td>
<td>10.59663</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>1.158517</td>
<td>1.126482</td>
<td>2.041569</td>
<td>1.214471</td>
<td>3.413961</td>
</tr>
<tr>
<td>Skewness</td>
<td>1.010896</td>
<td>-0.024401</td>
<td>-0.939595</td>
<td>-0.547103</td>
<td>-0.880927</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.531816</td>
<td>1.925104</td>
<td>2.897372</td>
<td>2.415392</td>
<td>2.208338</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>5.742451</td>
<td>1.495470</td>
<td>4.870093</td>
<td>2.116200</td>
<td>4.508120</td>
</tr>
<tr>
<td>Probability</td>
<td>0.056629</td>
<td>0.473438</td>
<td>0.087594</td>
<td>0.347115</td>
<td>0.104972</td>
</tr>
<tr>
<td>Sum</td>
<td>188.6421</td>
<td>296.1548</td>
<td>653.8305</td>
<td>717.2917</td>
<td>509.2383</td>
</tr>
<tr>
<td>Sum Sq. Dev.</td>
<td>41.60703</td>
<td>38.06888</td>
<td>133.3761</td>
<td>47.19809</td>
<td>326.3436</td>
</tr>
<tr>
<td>Observations</td>
<td>32</td>
<td>31</td>
<td>33</td>
<td>33</td>
<td>29</td>
</tr>
</tbody>
</table>
5.2 The Unit Root Test
The stationary series usually fluctuate around a fixed mean with a fixed variance. Augmented Dickey-Fuller Test is run for checking stationarity. The test is based on the following regression model;

$$\Delta Y_t = \beta_0 + \beta_1 Y_{t-1} + e$$

If the series is found non-stationary, then the same test is run with the first difference forms of the same series as;

$$\Delta^2 Y_t = \beta_0 + \beta_1 \Delta Y_{t-1} + e$$

The Dickey-Fuller stationary test is employed for every series. The series were found non-stationary in level and found stationary in first difference.

All series’ unit root test outputs in level and in first difference are given below;

Table 4 Unit Root Test Results for Series in Level

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test for Unit Root in</th>
<th>Include in test equation</th>
<th>Lag length</th>
<th>Augmented Dickey-Fuller Test Statistic</th>
<th>Probability (MacKinnon 1996, one sided)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln (GDP) level</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td>-3.1042</td>
<td>0.1219</td>
<td></td>
<td>It has a unit root</td>
</tr>
<tr>
<td>ln (GDP per Capita)</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td>-2.5208</td>
<td>0.3167</td>
<td></td>
<td>It has a unit root</td>
</tr>
<tr>
<td>ln (Gross Domestic Expenditure on R&amp;D)</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td>-2.3676</td>
<td>0.3849</td>
<td></td>
<td>It has a unit root</td>
</tr>
<tr>
<td>ln (Total Number of Researchers)</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td>-1.9046</td>
<td>0.6196</td>
<td></td>
<td>It has a unit root</td>
</tr>
<tr>
<td></td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------------------</td>
<td>-----------------------</td>
<td>---</td>
<td>---</td>
<td>------------------------</td>
<td></td>
</tr>
<tr>
<td>ln (Scientific and Technical Journal Articles)</td>
<td>level</td>
<td></td>
<td>1.5491</td>
<td>1.0000</td>
<td>It has a unit root</td>
<td></td>
</tr>
<tr>
<td>ln (Patent Applications)</td>
<td>level</td>
<td></td>
<td>-0.8349</td>
<td>0.9507</td>
<td>It has a unit root</td>
<td></td>
</tr>
<tr>
<td>ln (Trade Mark Applications)</td>
<td>level</td>
<td></td>
<td>-0.32096</td>
<td>0.1023</td>
<td>It has a unit root</td>
<td></td>
</tr>
<tr>
<td>ln (Export of Computer, Electronic and Optical Industry)</td>
<td>level</td>
<td></td>
<td>-1.3785</td>
<td>0.8481</td>
<td>It has a unit root</td>
<td></td>
</tr>
<tr>
<td>ln (Export of Aerospace Industry)</td>
<td>level</td>
<td></td>
<td>-1.3980</td>
<td>0.8393</td>
<td>It has a unit root</td>
<td></td>
</tr>
<tr>
<td>ln (Import of Computer, Electronic and Optical Industry)</td>
<td>level</td>
<td></td>
<td>-3.1367</td>
<td>0.1153</td>
<td>It has a unit root</td>
<td></td>
</tr>
<tr>
<td>ln (Import of Aerospace Industry)</td>
<td>level</td>
<td></td>
<td>-2.6263</td>
<td>0.2721</td>
<td>It has a unit root</td>
<td></td>
</tr>
</tbody>
</table>
Table 5  Unit Root Test Results for Series in First Difference

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test for Unit Root in</th>
<th>Include in test equation</th>
<th>Lag length</th>
<th>Augmented Dickey-Fuller Test Statistic</th>
<th>Probability (MacKinnon 1996, one sided)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln (GDP)</td>
<td>First difference</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td>-6.0073</td>
<td>0.0001</td>
<td>It does not have a unit root</td>
</tr>
<tr>
<td>ln (GDP per Capita)</td>
<td>First difference</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td>-5.9604</td>
<td>0.0001</td>
<td>It does not have a unit root</td>
</tr>
<tr>
<td>ln (Gross Domestic Expenditure on R&amp;D)</td>
<td>First difference</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td>-5.3798</td>
<td>0.0014</td>
<td>It does not have a unit root</td>
</tr>
<tr>
<td>ln (Total Number of Researchers)</td>
<td>First difference</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td>-5.4601</td>
<td>0.0012</td>
<td>It does not have a unit root</td>
</tr>
<tr>
<td>ln (Scientific and Technical Journal Articles)</td>
<td>First difference</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td>-3.6232</td>
<td>0.0481</td>
<td>It does not have a unit root</td>
</tr>
<tr>
<td>ln (Patent Applications)</td>
<td>First difference</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td>-7.5711</td>
<td>0.0000</td>
<td>It does not have a unit root</td>
</tr>
<tr>
<td>ln (Trade Mark Applications)</td>
<td>First difference</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td>-4.8625</td>
<td>0.0030</td>
<td>It does not have a unit root</td>
</tr>
<tr>
<td></td>
<td>First difference</td>
<td>Trend, Intercept</td>
<td>Schwarz info Criteria</td>
<td></td>
<td>It does not have a unit root</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------</td>
<td>-----------------</td>
<td>-----------------------</td>
<td>-------</td>
<td>----------------------------</td>
<td></td>
</tr>
<tr>
<td>In (Export of Computer, Electronic and Optical Industry)</td>
<td></td>
<td></td>
<td>-3.5212</td>
<td>0.0557</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In (Export of Aerospace Industry)</td>
<td></td>
<td></td>
<td>-7.7632</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In (Import of Computer, Electronic and Optical Industry)</td>
<td></td>
<td></td>
<td>-5.7907</td>
<td>0.0002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In (Import of Aerospace Industry)</td>
<td></td>
<td></td>
<td>-7.2655</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.3 Ordinary Least Square Models

Seven regression analysis were conducted. Each models dependent and independent variable(s) are summarized in the table below:

Table 6 Dependent and Independent Variables of Each Model

<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent Variable</th>
<th>Independent Variable(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>Patent Applications</td>
<td>Gross Domestic Expenditure on R&amp;D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Number of Researchers</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>GDP per Capita</td>
<td>Export of Computer, Electronic and Optical Industry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Export of Aerospace Industry</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>Trade Mark Applications</td>
<td>Patent Applications</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Export of Computer, Electronic and Optical Industry</td>
<td>Patent Applications</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Export of Aerospace Industry</td>
<td>Patent Applications</td>
</tr>
<tr>
<td>6&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Patent Applications</td>
<td>Scientific and Technical Journal Articles</td>
</tr>
<tr>
<td>7&lt;sup&gt;th&lt;/sup&gt;</td>
<td>GDP</td>
<td>Import of Computer, Electronic and Optical Industry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Import of Aerospace Industry</td>
</tr>
</tbody>
</table>

The regression analysis outputs are given below:
<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-16.15260</td>
<td>2.243575</td>
<td>-7.199495</td>
<td>0.0000</td>
</tr>
<tr>
<td>(\ln(\text{Gross Domestic Expenditure on R&amp;D})_{t-1})</td>
<td>0.337428</td>
<td>0.237931</td>
<td>1.418180</td>
<td>0.1723</td>
</tr>
<tr>
<td>(\ln(\text{Total Number of Researchers}))</td>
<td>1.445952</td>
<td>0.298371</td>
<td>4.846149</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

- **R-squared**: 0.977191
- **Mean dependent var**: 6.309403
- **Adjusted R-squared**: 0.974790
- **S.D. dependent var**: 1.183703
- **S.E. of regression**: 0.187943
- **Akaike info criterion**: -0.379232
- **Schwarz criterion**: -0.230453
- **Hannan-Quinn criter.**: -0.344184
- **Durbin-Watson stat**: 0.667817
- **Prob(F-statistic)**: 0.000000
Table 8  Second Model’s Output

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.028771</td>
<td>0.667591</td>
<td>6.034790</td>
<td>0.0000</td>
</tr>
<tr>
<td>ln(Export of Computer, Electronic and Optical Industry)</td>
<td>0.231696</td>
<td>0.048610</td>
<td>4.766379</td>
<td>0.0001</td>
</tr>
<tr>
<td>ln(Export of Aerospace Industry)</td>
<td>0.017698</td>
<td>0.021606</td>
<td>0.819159</td>
<td>0.4201</td>
</tr>
</tbody>
</table>

R-squared 0.850647  Mean dependent var 9.022833
Adjusted R-squared 0.839159  S.D. dependent var 0.440599
S.E. of regression 0.176702  Akaike info criterion -0.531003
Sum squared resid 0.811817  Schwarz criterion -0.389558
Log likelihood 10.69954  Hannan-Quinn criter. -0.486704
F-statistic 74.04233  Durbin-Watson stat 0.236355
Prob(F-statistic) 0.000000

Dependent Variable: ln(GDP per Capita)
Method: Least Squares
Sample (adjusted): 1984 2012
Included observations: 29 after adjustments
### Table 9  Third Model’s Output

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.215158</td>
<td>0.538032</td>
<td>7.834393</td>
<td>0.0000</td>
</tr>
<tr>
<td>ln(Patent Applications)</td>
<td>0.918111</td>
<td>0.091022</td>
<td>10.08674</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

**R-squared**: 0.778190  
**Mean dependent var**: 9.553382

**Adjusted R-squared**: 0.770541  
**S. D. dependent var**: 1.126482

**S. E. of regression**: 0.539606  
**Akaike info criterion**: 1.666386

**Sum squared resid**: 8.444069  
**Schwarz criterion**: 1.758902

**Log likelihood**: -23.82899  
**Hannan-Quinn criter.**: 1.696544

**F-statistic**: 101.7424  
**Durbin-Watson stat**: 0.189767

**Prob(F-statistic)**: 0.000000
Table 10  Fourth Model’s Output

Dependent Variable: ln(Export of Computer, Electronic and Optical Industry)
Method: Least Squares
Sample (adjusted): 1981 2012
Included observations: 31 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>12.86412</td>
<td>1.277399</td>
<td>10.07056</td>
<td>0.0000</td>
</tr>
<tr>
<td>ln(Patent Applications)</td>
<td>1.186284</td>
<td>0.211607</td>
<td>5.606065</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

R-squared: 0.520090  Mean dependent var: 19.89550
Adjusted R-squared: 0.503541  S.D. dependent var: 1.913143
S.E. of regression: 1.347998  Akaike info criterion: 3.497459
Sum squared resid: 52.69585  Schwarz criterion: 3.589974
Log likelihood: -52.21061  Hannan-Quinn criter.: 3.527616
F-statistic: 31.42796  Durbin-Watson stat: 0.119892
Prob(F-statistic): 0.000005
Table 11  Fifth Model’s Output

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>6.166454</td>
<td>2.591204</td>
<td>2.379764</td>
<td>0.0246</td>
</tr>
<tr>
<td>ln(Patent Applications)</td>
<td>1.900535</td>
<td>0.424467</td>
<td>4.477461</td>
<td>0.0001</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.426114</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.404859</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>2.633714</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>187.2841</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-68.19651</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>20.04766</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
<td>0.000124</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 12  Sixth Model’s Output

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.523632</td>
<td>0.847059</td>
<td>-0.618177</td>
<td>0.5421</td>
</tr>
<tr>
<td>ln(Scientific and Technical Journal Articles)</td>
<td>0.831428</td>
<td>0.107869</td>
<td>7.707738</td>
<td>0.0000</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.703824</td>
<td></td>
<td></td>
<td>5.941637</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.691977</td>
<td></td>
<td></td>
<td>1.104568</td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>0.613033</td>
<td></td>
<td></td>
<td>1.930392</td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>9.395248</td>
<td></td>
<td></td>
<td>2.026380</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-24.06030</td>
<td></td>
<td></td>
<td>1.958935</td>
</tr>
<tr>
<td>F-statistic</td>
<td>59.40922</td>
<td></td>
<td></td>
<td>0.095695</td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
<td>0.000000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dependent Variable: ln(Patent Applications)
Method: Least Squares
Sample (adjusted): 1985 2011
Included observations: 27 after adjustments
All independent variables’ parameter signs were found positive as they were expected. $R^2$ of all seven analyses are over 50 percent. Export of Aerospace Industry and Import of Aerospace Industry variables’ parameter’ t-statistics values are a low in model 2nd and model 8th. Gross Domestic Expenditure on R&D variable parameter’s t-statistics
value is significant at the 80 percent confidence level. The Rest of the independent variables’ parameter t-statistics are significant at the 95% confidence level.

5.4 Co-integration Tests

The Engel-Granger method is used to check co-integration between variables’ series. This test is usually employed to check long-run relationships between dependent and independent variables. All series were found non-stationary in level and stationary in first difference.

If the residual of each OLS model is stationary at level I (0), then a long run relation between variables can be assumed. In other words, the series are co-integrated. The residual time series’ Augmented Dickey Fuller test results are given below:

Table 14 All Models’ Residual Unit Root Test

<table>
<thead>
<tr>
<th>Model</th>
<th>Test for Unit Root in</th>
<th>Include in test equation</th>
<th>Augmented Dicky-Fuller Test Statistic</th>
<th>Probabili-ty (MacKinnon 1996, one sided)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Model</td>
<td>Level</td>
<td>None</td>
<td>Schwarz info Criteria</td>
<td>-2.4226</td>
<td>0.0180</td>
</tr>
<tr>
<td>2nd Model</td>
<td>Level</td>
<td>None</td>
<td>Schwarz info Criteria</td>
<td>-0.6313</td>
<td>0.4344</td>
</tr>
<tr>
<td>3rd Model</td>
<td>Level</td>
<td>None</td>
<td>Schwarz info Criteria</td>
<td>-2.0936</td>
<td>0.0368</td>
</tr>
<tr>
<td>4th Model</td>
<td>Level</td>
<td>None</td>
<td>Schwarz info Criteria</td>
<td>-2.0237</td>
<td>0.0429</td>
</tr>
<tr>
<td>5th Model</td>
<td>Level</td>
<td>None</td>
<td>Schwarz info Criteria</td>
<td>-2.5086</td>
<td>0.0144</td>
</tr>
</tbody>
</table>
Innovative Developments and Economic Growth: The Case of Turkey

6th Model | Level | None | Schwarz info Criteria | -1.9468 | 0.0511 | It does not have a unit root

7th Model | Level | None | Schwarz info Criteria | -3.1597 | 0.0025 | It does not have a unit root

2nd Model’s residual was found non-stationary in level. This means that the regression model results do not work in the long-run. But the rest of the 6 models (1st, 3rd, 4th, 5th, 6th and 7th) residuals were found stationary in level. The variables of each models fluctuate together and have long run relationships.

6 ANALYSIS AND RESULTS
Two types of analysis were used during this study. These analyses’ outputs are summarized under short-run and long-run headings.

6.1 Short-Run Analyses
There were 7 ordinary least square models used for short-run analysis. Each models’ dependent and independent variables are given in Table 6.

The first model’s dependent variable was patent applications in Turkey. The independent variables are gross domestic expenditure on R&D and total number of researchers. Least square model’s output is given in Table 7. The effects of each independent variable on the dependent variable was found positive in the model. The number of researchers’ influence on patent application is almost 4.5 times greater than R&D expenditure. R-square value was found quite high.

The second model aims to test the export of computers, electronic, optical industries and the export of aerospace industry on GDP per capita. Both independent variables effects on dependent variables were found positive. Export of aerospace industry could explain why the GDP per capita growth is very limited and the same variable’s t-statistics value is very low. R-square was calculated as 85 percent.

The third model was designed to shed light on the interrelation between total trade mark applications and total patent applications. According to ordinary least square model, there is a positive relation
between two variables. The independent variable’s (total patent applications) t-statistic value was found significant at 99 percent. R-square value was 77 percent.

The forth model’s independent variable is total patent applications. The dependent variable is the total export of computer, electronic and optical industry. Total patent application can explain growth in the export of computer, electronic and optical industry. Standard error of independent variable is quite low and the adjusted R-square value is almost 50 percent.

The fifth model shows the relation between total number of patent applications and total aerospace industry export in Turkey. The total number of patent application is independent variable in the least square model. Signs of independent variables is found positive as was expected. The number of patent application's t-statistic value is inside the 90 percent significance boundary. The r-square value is 42 percent.

The sixth model aims to check the interrelation between the total number of articles which were published in scientific journals and the total number of patent applications. The total number of published papers is the independent variable of the model. Independent variable’s coefficient was found 0.83 and its standard error is low. The Independent variable can explain the 70 percent changes in the dependent variable.

The seventh and last model was used to explain GDP growth by two inputs which are the total import of computer, electronic, optical industry and total import of aerospace industry. Both independent variables’ coefficients signs were found positive. According to coefficients’ magnitudes: the influence of total import of aerospace industry on GDP is less than the total import of computer, electronic, optical industry. The t-statistic value of total import of aerospace is very low while the total import of computer, electronic and optical variable’s t-statistics is in the 90 % confidence interval. The R-square is calculated as 90 percent.

6.2 Long-Run Analyses

According to the Engel-Granger method, there can be a long-run relationship between dependent and independent variables if the series of least square model are non-stationary in level, and the least square model’s residual is stationary in level. The residual series of the 7 models
are tested in long-run analysis. The unit root test is run and the tests results are given in Table 14.

Long-run interrelation is found in 6 models out of 7 models. These models model numbers are 1, 3, 4, 5, 6 and 7. These least square model's residuals were found stationary in level. In other words, there are no unit roots found in those residual series.

No co-integration was found in model 2. The residual series of the second least square model was found non-stationary in level which shows that the series has unit root.

7 CONCLUSION

The determinants of technological progress and economic growth in Turkey were examined in this paper. It can be seen that all independent variables in the seven models provided, have a positive influence on economic growth in the short run. However, the long-run analysis results suggest that independent variables such as the export of computers, electronics, optical industry and Aerospace industry products do not have a positive effect on GDP per capita.

The results indicate that compared to the other models, the first model of Gross Domestic Expenditure on R&D and Total number of researchers has a considerable positive effect on Patent Applications. New research can thus focus on an index which explains the multiple linear relations in the progress of technology.

A strong relation was found between total patent applications and total trade mark applications during the years between 1980 and 2011 in model 3. The patent and trade mark applications dramatically increased simultaneously during this period in Turkey. New inventions are patented first in national patent office and the new trade mark applications are done for the new invented product in the same office.

A Positive influence of total patent applications on total export of computer, electronic, optical industry was found in model 4. Any increase on patent application had a remarkable effect on total Turkish technologic export. Growing export values were clarified by patent application over the past decade. In addition, patent applications had a positive affect on aerospace industry exports. Aerospace industry has been developed for the last two decades. Furthermore, new technological
inventions which are registered by national patent office triggered the aerospace industry production and aerospace industry export.

Patent application are encouraged by Scientific and technical journal articles. This econometric relation was found to be very significant. Scientific papers which written in Turkey have increased dramatically over the last decades. This increase on the publishing of scientific papers, supported the increase on patent application.

Technology import such as computer and aerospace imports has a weak positive effect on GDP growth. Computer and aerospace imports are called basic inputs of technology production.

The relation between export of computer-aerospace industries and economic (GDP) growth is econometrically significant in short-run. Nonetheless, no long-run relation was found between these variables.

REFERENCES


Innovative Developments and Economic Growth: The Case of Turkey


**KEY TERMS**
- Endogenous Growth
- Higher Education
- Hi-tech R&D
- Modelling
- Patenting
- Productivity
- R&D Intensity
- Technology Transfer

**QUESTIONS FOR FURTHER STUDY**

Compare R&D intensity and economic growth rate figures during the last two decades.

Describe the inter-relation of patenting and technology export.

Explain the relationship between total number of scientific paper publications and economic growth.

Design a technology function which has a direct effect on aggregate production.
EXERCISES
What are some of the reasons which led to the Japanese great economic growth that occurred between 1950 and year 2000. How can the Japanese government achieve a high growth rate once more?

Clarify the possible reasons of Argentina's economic decline in the first half of the 20th century. What can Argentina's cabinet do to improve technological progress.

Compare the economies of Ireland and South Korea during the 1990s. Research the facts behind South Korea's economic growth and Ireland’s economic recession after the year 2000.

FURTHER READING
Wiel, D.N. Economic Growth. Addison Wesley. 2004
LEARNING OBJECTIVES
Once you have mastered the materials in this chapter, you will be able to:
- explain the developments regarding technology,
- identify different types of innovation,
- understand the importance of technology in innovation,
- identify the new technologies in business organizations,
- discuss how technology impacts on innovation.

CHAPTER OUTLINE
This chapter reveals how the recent rapid transformations in technology affect the business world and businesses in a conceptual framework. In this context, primarily the effects of technological developments on organizational structure, business models and the business process were addressed, and subsequently, the most commonly employed technological instruments in the business world and their major benefits were defined. In the subsequent chapters of the study, the effect of technology on innovation was investigated and discussed on the basis of empirical studies.

KEYWORDS
Technology, innovation, organizational structure, business process, business model.
1 INTRODUCTION
Recently, particularly in highly competitive sectors, it has been emphasized that the innovation capacity of companies has become important for success. For this reason companies put the issue of innovation on their agendas and focus on the preservation and development of their positions in the market by creating innovation. Today, innovation has been added to the managers’ agenda even in traditional goods and service sectors where changes to products are minimal. There are many studies defining and explaining innovation; these studies also point out several different internal and external elements that played a role in the emergence of innovation in business. This conceptual paper aims to investigate the effects of technology use on innovation processes in the light of the recent literature. In this context, we first attempt to redefine the understanding of business and applications. In the following section, new technologies in the most recognized manner are presented as four different categories. Finally, the effects on innovation of these technologies, which are widely used in business, are discussed.

2 TECHNOLOGY AND THE NEW BUSINESS STRUCTURE
Nowadays, developments in information technologies in business life have gained considerable pace. Technically, digital technologies have developed incredibly in the last 30 years (De Kare-Silver 2011). It is well known that these changes and transformations heavily influence the technologies that are applied in the business world, business organizations, the employees of these businesses and their customers, and the processes between all of these.

Technologies that appear over time rapidly change enterprises’ structures, processes, customers, suppliers, interaction and networks. The development of mass production and the use of main frame computers lasted for about twenty years whereas mobile devices began to be used widely after seven years of development and social media after three years (De Kare-Silver 2011). Today, most technologies are available for users less than a year after their development.

When the general status of entrepreneurism is considered, this recent technological transformation can be analyzed through a few basic focus points. In the first stage, it is observed that this transformation
makes an impact on business models. With this transformation, several new business models and organizational structures have emerged. The relations between businesses have become more elaborate. Secondly, it should be emphasized that this transformation shapes business processes considerably. For example, it is clear that the occurrence of this technological transformation covers a wide scope ranging from communication methods of the business with its employees and customers to traditional administrative practices and from sales channels to public relations activities. In the following study, three basic areas that experienced changes due to the penetration of technologies in business life are examined under the following titles: the impact of technology on organizational structure, business models and business processes.

2.1 Impact of Technology on Organizational Structure
The most apparent effect of technology use in business occurs on the organizational structure. Technology affects both ways of doing business and ways of coordination of these businesses. These technologies allow organizations to have fewer mistakes, easier control, and less problematic production. They also help managers to make better decisions and to establish control through various information systems and provide faster access to the information needed. Nowadays, in order to make organizations effective, managers are required to manage information, promote information technologies for employees and transform their companies into learning organizations.

In addition, information technologies in organizations influence the scope of business, the functions of employees and their required properties. Technological developments have caused a change in the labor force. An educated and specialized profile has come into prominence. From this point of view, the number of information workers has increased. Traditional working skills have been replaced by new skills that are based on dynamism and flexibility. In such an environment, with the support of technology, new organizational structures emerged (Scarbrough and Corbett 2013). For example, today many businesses spend their capital on creating virtual organizations or an online portfolio by using new technological tools. The organizations, which operate with the mentality of inexpensive but higher quality
service, benefit from information technologies and form virtual organizations (Holtshouse 2013). Furthermore, consideration of information technologies together with a flexible working environment has brought flexible working concepts such as teleworking, which is a new way of working and living today. These concepts are expressed in different ways, such as employment at home or mobile work; they provide opportunities for employees such as part-time work, working on networks, division of labor and mobile working (Coenen and Kok 2014). It is estimated that flexible working, together with digitalized working processes, will remain popular in time to come. In summary, due to novelties in information technologies, the classical organizational model has been replaced by a virtual organizational model, which operates 24/7 and provides goods and services to customers who are independent from a physical site. This model has brought several novelties in product and service marketing, sales and customer relations.

2.2 Impact of Technology on Business Models

Another area in which technological developments have had significant effect is the business models that are employed by business. The rapid spread of the internet has made electronic commerce a new and very effective tool in the execution of commercial activities. Businesses change their organizations and working styles in order to adapt to this type of commerce. They abolish barriers between company-customer-supplier through e-commerce and m-commerce. Together with this changing style of consumer, sellers have the opportunity to sell their products and services to the whole world, and buyers are able to select the presented products and services easily (Barnes and Hunt 2013). E-commerce activities on open networks have increased electronic communication; this situation has enabled businesses to reach all customers and other businesses in a more inexpensive and easier way. Many businesses have become able to market their products through this method without establishing a marketing network. With these structures, which bring superiority in competition and an increase in service quality, sellers have become closer to their customers and gained a competitive advantage over their competitors. Due to technological developments, E-commerce enables a decrease in costs of production, and marketing and distribution activities and this has provided a
competitive advantage to enterprises on national and international levels and increased competition. Thanks to these structures, companies can establish customer needs in a detailed and fast way and they are now able to present special services at more economical prices (Onetti et al. 2012). Due to the rapid change of technology, today companies are able to deliver goods and services to customers through m/e-commerce and without recourse. For this reason, cost and time have become advantageous for both seller and buyer. The time period between order and delivery of products is kept to the minimum, time-oriented costs and inventory costs are reduced and intermediaries are not used. As transactions in the electronic environment cost much less than normal transactions, both seller and buyer are able to save considerable amounts of money. Documents that are needed for electronic commerce are prepared in the electronic environment and this information and the documents are made available to whom they may concern. Thus, these transactions are done with minimum errors in a rapid way and without red tape costs. E-commerce has changed the relative importance of time, the significance of geographical proximity to the market has been challenged and efficiency on behalf of the enterprises increases through web-based marketing (Zhang and Wang 2015).

In discussing the impacts of technology on business models, it is important to separately analyze another technological tool called the internet, which has left its mark on the last quarter-century. Web-based technologies, which are popular ways of doing business online, bring buyer and seller into the same digital environment and provide entrepreneurial opportunities. It is also observed that the perception of digitalization was brought into question rapidly by industrial companies. Due to the web applications that are formed through user friendly interfaces, companies can present designing options to customers about desired goods and services. They can obtain feedback from customers about these goods and services and they can sell them on the same platforms. In addition, the increase of sales of goods and services on social media encourages companies to use these tools and to invest in these channels.
2.3 Impact of Technology on Business Processes

When the effects of technology on business processes are considered, it is important to emphasize that technology has particularly changed communication types. This change can be analyzed in a broad perspective ranging from communication between employees within the business to the types and tools of communication with customers. This platform, which includes the coexistence of different communication types, that is to say unified communications, helps to differentiate user habits and business processes of the employees, makes rapid communication possible in daily life environments and influences ways of doing business. These structures are particularly compatible with mobile working environments. They provide ways of doing business that are independent of time and place. Due to the unified communications technologies, managers can easily administer staff that work in different places and supervise their performance by using unified infrastructures. Today's working and living spaces have changed due to the concept of mobility. Smart phones and tablets play an important role in this situation. As the skills of unified communication systems develop, their effectiveness in business life also increases. These technologies are preferred by more and more business especially for reporting. It is observed that the employees who use these devices during business processes are happier and have better motivation. These devices also provide efficiency and savings for business. In terms of employees, technological changes caused the digitalization of many business processes in both the public and private sectors. These changes provide more flexible and mobile working conditions and influence employees who can log in to the system in any environment. Moreover, most of the processes and services are transferred to the electronic environment so that customers can benefit from these services in an easy and quick way (Davenport 2013). Internet provides the infrastructure for the data sharing and cooperation of employees. Companies can gather employees in different geographical locations through tools such as newsgroups and chat rooms, establish working groups and operate transactions through virtual platforms. In terms of customer relations, companies make use of audio and visual elements in an interactive way and can sell their products to customers in virtual shops.
Another support mechanism that is provided by technology to businesses is information management. Offline data storage systems, which are used widely nowadays, are inefficient to store, process and archive high volume data; therefore they channel big data phenomena to cloud computing. Big data analytics, social media analysis and data mining applications that are presented on cloud computing make companies more efficient. They introduce a totally new understanding in order to reduce storage costs, facilitate business processes and maximize profits. Thanks to these structures, businesses are able to produce more beneficial and useful information from current data and market this information to other companies. Cloud computing eliminates operating costs such as renovation of hardware, maintenance, software update storage caused by servers and data storage systems that are established within the companies. In the big data age, it also contributes to new age working solutions with its right perspective towards data storage and processing. With digitalization, information is stored in the electronic environment. Therefore, managers and employees can have direct access to information anywhere and anytime they need.

3 THE NEW TECHNOLOGIES IN BUSINESS ORGANIZATIONS

3.1 IT and Business: The Journey of Technology

Although the tech wave has existed for a long time, it has recently gained considerable pace. The last decade witnessed noteworthy developments in digital technologies. Web 2.0 began to be used widely in 2004 and this initiated a new period in content generation for the World Wide Web. The rise of Facebook, Twitter, Wikipedia and other user-generated content tools has really created a new version of the web. In addition, new generation computing devices, particularly iPhone and iPad, which were released by Apple respectively in 2007 and 2010, have pioneered the age of the smart phone and tablets. They were also important steps and expectation-leading devices for mobile computing. The most important outcome of this fascinating development in technology is the radical change in the lives of individuals and the ways that businesses conduct business (Westerman et al. 2014).

Nowadays, technology and its use are very important for business. Although globalization and off-shoring are key factors in determination of the strategies of business, technology precedes these factors.
Digitalization has abolished limits on many spheres of life. It is creating new possibilities influencing individuals’ lives and business. Businesses, which desire to know about their customers independently from surveys or focus groups, use social networks whereas businesses that desire employees to be independent from time and place and efficient use mobile computing. Big data considerably facilitates business to make better decisions. Businesses, which aim to achieve new organizational structures and business processes, to present new offers to their customers and to renew these processes as conditions change, can easily accomplish these processes with the help of technology (Westerman et al. 2014). In the following section we list and attempt to explain the most important and recognized technologies that have led to the transformation of business.

3.2 Cloud Computing

Cloud computing is commonly used new technology in the business world. Cloud computing is a global technology including an alternative path that can be used by any sort of business to possess an information system. Although there are several definitions for cloud computing, the most accepted was made by the National Institute of Standards and Technology (NIST):

“Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.” NIST, U.S. Department of Commerce, http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800–145.pdf

In today’s competitive world, businesses are well aware of the fact that they need a reliable computing system in order to achieve their goals. Particularly for small and medium sized businesses, having a functional computing system means time and cost. Since cloud computing has become an applicable option, many business decided to use this service (Srinivasan 2014). Cloud computing was developed from a traditional outsourcing model. In this model, the service that is necessary for business is developed by a specialized company. Small and medium
sized businesses usually prefer to make a deal with a specialist for the management of information systems instead of outsourcing. The basic point that makes cloud computing attractive for business is the fact that a system, which is selected for a fully functional computing system, can be owned in a few hours or in a few days, depending on its complexity level. The cloud computing platform provides all possible options ranging from the necessary type of hardware to service type and from applications to storage quantity. Customers can access the system via the internet. Customers who want to perform their communications on a higher protection level with cloud can use Virtual Private Network (VPN) that is provided by an Internet Service Provider (ISP). Access to cloud is proportional to ISP connection speed (Hurwitz et al. 2012). Another important benefit provided by cloud services to business is to increase or decrease computing resource use. At the same time, business pay-per-use can reach a wide variety of applications without a license. The most important contribution of all these opportunities to business is that they do not have to manage the service that is needed. Therefore, source and time use of the business is reduced considerably. Customers can choose among cloud service providers. Outsourced and mostly niche service clouds such as payroll processing, human resource management and customer relations management (CRM) can be used as services. Cloud computing service has several service types and deployment models.

The most common service types are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). The most common service deployment models are Public cloud, Private cloud, Hybrid cloud and Community cloud. The major cloud service providers are Amazon Web Services (AWS), Microsoft Office 365 and Windows Azure, Google Apps, Rackspace and Salesforce. AWS is the largest cloud service provider worldwide. It provides office software such as Office 365, Word, Excel, PowerPoint and Outlook. It enables access to storage and database services like Azure Skydrive and includes several niche services such as Google Apps Gmail, Google Docs and Google Drive. It has basic cloud services including Rackspace web hosting. Salesforce is a world leader in cloud-based CRM software (Srinivasan 2014).
Figure 1 shows cloud service models that are defined by NIST. The first model layer is Software as a Service (SaaS) when going upwards to the physical layer. SaaS provides both server hardware and software to businesses that are freed from the complexity of IT system management. SaaS represents all software-based services that can be accessed on the internet and employed outside of the institution. The simplest example for SaaS can be an e-mail service for a business. Google’s Gmail is one of the popular cloud computing applications. A business can adopt Gmail without considering maintenance, security, uptime and infrastructure management (Hill et al. 2013). The end user receives e-mail service but does not think about how it is provided. In addition, these services enable employees to access private files and folders and also institutional computer applications on the internet. Private database applications, archive and backup solutions, online messaging and meeting applications are among the services that can be used in this category. Thanks to this service, applications can be reached by any device that is connected to the internet. Applications can be used both for personal and institutional use. Maintenance, updates and high-availability of the application are done by SaaS constantly. Instead of the institution's data center, applications in the data center help to build a faster and more secure structure. Today, large commercial SaaS providers are Amazon, Google, Microsoft and Salesforce.

Platform as a Service (PaaS) is located just under SaaS. PaaS gives more freedom to the subscriber in selecting the desired computing
platform. It provides the necessary platform to persons and institutions to develop some applications. For example, it provides convenient hardware, software and various components that are needed by a software developer in order to develop certain software. Unlike the SaaS user, the PaaS user should have sufficient numbers of computer specialists in order to manage the platform of which he is a member. Similar to SaaS, PaaS is also compatible with pay-as-you-go models. PaaS provides server capacity to customers to operate applications and a platform such as the Windows operating system. Users have to take care of the security of the platform that they use. For instance, if a user works with SQL Server database on his platform, he should be aware of security gaps of the database systems. In addition, customers should know about applications that are used on the platform. Another benefit that PaaS brings to users is that when there is a need for change of hardware for the applications on a platform or a Linux/UNIX platform is needed, PaaS can complete a task in a few days instead of new systems information, which can last a few weeks. Google App Engine, Salesforce.com and Windows Azure are examples of PaaS providers.

Infrastructure as a Service (IaaS) is known as a service referring to all hardware, network equipment and storage units that are needed by an institution. It provides the same properties as PaaS to customers but they are totally responsible for leased infrastructure control. IaaS is also known as “utility computing” as they do not directly invest computer resources that they need but use resources. The service provided here consists of the hardware and related services (data centers, physical hardware, networking equipment and firewalls etc.). IaaS is the most expensive of these three models and is used by large scale business. The most significant advantage that this platform provides to businesses is that they do not need to make hardware investment. Moreover, other important gains are flexibility and pay-per-use systems. At the same time, businesses are not obliged to make constant investments. IaaS's simplification of management and dynamic activities makes it more important (Rimal et al. 2011). Amazon, Rackspace, Xerox and IBM are examples of IaaS providers. The size of the business is directly correlated with which of these three cloud services meet customer needs on different hardware and software levels. There are deployment models that are associated with service types. These models can be
classified as Public Cloud, Private Cloud, Hybrid Cloud and Community Cloud. Public cloud is the most popular and it constitutes the basic cloud computing structure. A public cloud, as its name dictates, can be reached by the general public. It is the sharing of all services on the internet between multiple institutions, associations and individuals. Small and medium sized businesses generally use this model. In general, large scale businesses do not want to carry their own critical structures and applications on the public cloud due to security concerns (Li 2011). Private cloud provides customers with a higher level of control but it is a more expensive service than public cloud. Therefore, it is used only by large businesses. Community cloud meets the private needs of business in certain sectors such as automotive, energy, financial sectors and health care. Community cloud is a closed system and only member organizations can use it. Hybrid cloud is a composition of two or more different cloud infrastructures (private, community or public) (NIST, 2011).

Table 1 summarizes the benefits of cloud use to enterprises of different sizes. Businesses of different sizes make use of the advantages of cloud service in different ways. Small and medium sized businesses can reach costly computing services through cloud. Cloud service providers operate on the basis of the pay-per-use principle. Large corporations such as Microsoft and Adobe have begun to present their products on cloud without complicated license processes. All Microsoft Office’s 365 Office Suite applications can be used on the internet. Similarly, Adobe’s PDF and PhotoShop products can be accessed via cloud. At the same time, cloud users can easily communicate with other users and share their work. Without cloud infrastructure, access to this type of service is costly for users and they cannot easily share their work with other users.
Table 1  Summary of business benefits for use of cloud computing

<table>
<thead>
<tr>
<th>Business Benefit</th>
<th>Small business</th>
<th>Medium sized business</th>
<th>Large business</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service availability</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Service reliability</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Meeting demand elasticity</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Ability to pay-as-you-go</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Service automation</td>
<td>–</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Email support</td>
<td>✓</td>
<td>✓</td>
<td>–</td>
</tr>
<tr>
<td>Database support</td>
<td>✓</td>
<td>✓</td>
<td>–</td>
</tr>
<tr>
<td>Customer relations management support</td>
<td>–</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Access control support</td>
<td>–</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Security</td>
<td>–</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Business continuity</td>
<td>–</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Data storage</td>
<td>–</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Data backup and recovery</td>
<td>–</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Meeting regulatory compliance</td>
<td>–</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Meeting industry compliance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>


In addition, the issue of storage, caused by data increase, is an important problem for businesses. At the same time, storage causes information security problems for businesses. Cloud storage presents very effective
solutions for this situation. Cloud services support business continuity with their capacity to store data in different locations and to provide access from different locations (Srinivasan 2014).

3.3 Web 2.0 and Social Networks

Other new technologies employed in the business world are Web 2.0 and social networks. Web 2.0 was developed after the web 1.0 period in which users could only see internet sites but could not change content. In Web 2.0 users can intervene in content in different ways. Another concept that is accompanied by Web 2.0 is social media. Although these two concepts are used with similar meanings, they are different. Social media include activities of individuals in a society who get together online, use conversational media and share information and opinions. Conversational media are the web-based applications that are used to deliver content in word, image, video or audio format. Web 2.0 might be perceived as a new version of the World Wide Web. However, it not. When we explain this situation with an analogy, in which the World Wide Web is like a highway, Web 2.0 refers not only to upgrading the highway to four lanes but also to developing different alternatives of vehicles to travel on it (Kaplan and Haenlein 2010; Safko and Brake 2009).

Social networks (Facebook, LinkedIn, Google+ etc.), which appeared in 1997 with SixDegrees, have become very popular internet platforms. Initially these networks were designed for personal use but later they have become targets for businesses that aim to promote their products and brands. Nowadays, businesses that desire to increase communication and interaction with customers have carried their activities online and gradually increased their use of social networks. Social networks offer new opportunities to businesses and enable them to establish closer relations with their customers.

Businesses can investigate trends and approvals of users about a product on social networks for product development and market research. They can launch social media campaigns for marketing and sales activities and through them they can establish private advertisements. In addition, they provide online support by designing social network pages for customer services and after sales support. Social networks at the same time play a role in human resources departments, in hiring
people for businesses. Businesses look at applicants’ histories on social networks and search engines and reach more detailed information about them. Table 2 shows business areas where social networks are used.

Table 2  Business areas of application of online social networks

<table>
<thead>
<tr>
<th>Business Area</th>
<th>Selected Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research and development</td>
<td>Product development, Market research</td>
</tr>
<tr>
<td>Marketing and sales</td>
<td>Marketing campaigns, Word-of-mouth marketing, Targeted advertising, Social CRM</td>
</tr>
<tr>
<td>Customer service</td>
<td>Customer support, After sales support</td>
</tr>
<tr>
<td>Human resources</td>
<td>Recruiting, Employer branding</td>
</tr>
<tr>
<td>Internal applications</td>
<td>Expert search, Collaboration in virtual teams, Knowledge management</td>
</tr>
</tbody>
</table>


Businesses can include social network users in the research and development process. For example, users on “open source spaces” can develop software, share information and gather together to discuss their innovative ideas. Including their customers as innovators in the product development process will help businesses to make important predictions concerning customer needs. There are many businesses that employ social networks in product development. An automotive company, Fiat, included more than 170,000 customers in the product development process on social media for the design of the Fiat 500 model and acquired this design free of charge. Similarly, the Lego Company shaped its new
Lego design according to the comments of its customers. The volume of accessible data on newsfeeds and groups brings many benefits to market research. Another area that can be used by businesses is marketing and sales. Social networks might be used as an effective and active marketing channel in various business activities such as conducting marketing, word-of-mouth marketing or targeted advertising. Here, the main idea is to make thousands of people know about products and services of a company due to people’s conversations with their friends. Studies emphasize that the performance of a business increases when the social structure of a social network on Viral Marketing Campaigns is taken into consideration. Current literature shows that people trust user comments more than advertisements (Bampo et al. 2008; Ermecke et al. 2009; Heidemann et al. 2012). Nevertheless, social networks cause considerable advantages as traditional advertising is in decline. Another field in which social networks developed is social Customer Relationship Management (CRM). This “social” concept attached to CRM brings important contributions in generating business values and analyzing future job opportunities. Every day more and more companies begin to use social networks as new channels of sales. Businesses include promising fields in social network applications to create a value chain. In generation innovation, providing social support, enhancing knowledge and increasing sales through marketing campaigns, social network use is beneficial in many perspectives. Huge amounts of data, the rapid spread of information on social networks and effective use of social networks will reduce costs and increase profits (Bonchi et al. 2011).

On the other hand, the use of social networks in the business context is accompanied by several difficulties and risks. Businesses, marketing agencies or media giants generally believe that the use of social networks as a new channel is enough to solve their problems. However, businesses should firstly deeply analyze social networks and their purposes. In order to create business value, they should determine what kind of business functions social networks require (Clemons 2009). Another difficulty that businesses can face on social networks is their loss of control over social network content. In fact, social networks are open to risks. Loss of control of social network content might cause unintended consequences. However, businesses should be aware of all these risks; they should consider the status of the business, its sources, culture and
know-how and develop an outcome-oriented strategy to minimize risks. This will bring success for businesses.

3.4 Web 3.0
Web 3.0 is also called the semantic web. Google’s CEO Eric Schmidt defines it as “applications which are pieced together - relatively small, the data are in the cloud and it can be run on any device (pc or mobile), very fast, very customizable and distributed virally (social network, email, etc.)”. Yahoo founder Jerry Yang defined web 3.0 with these words:

“.. you don’t have to be a computer scientist to create a program. We are seeing that manifest in Web 2.0 and 3.0 will be a great extension of that, a true communal medium ... the distinction between professional, semi-professional and consumers will get blurred, creating a network effect of business and applications”.

Web 3.0 has become very popular in the last few years due to its development of applications and services. Nowadays, search engines can find more accurate and target-oriented information, and users can establish better contacts with friends through social media applications. Due to the increasing capacity of saving and storing knowledge, it became more useful and preferable for web users. Social web, semantic web, web 3D and media-centric web can be considered as some key elements of Web 3.0.

Recently, social networks have become media where like-minded people and community groups share their ideas through Web 3.0 instead of giving links to documents. Social web is considered an effective and attractive way to communicate with people anywhere on the globe. Semantic web is an evolving and extensive version of Web 3.0; it enables people to find information at a much deeper level in the meaning of the terms that are searched and the context that is used. Machines, just like human beings, can read and understand such structured information without any uncertainty. Web 3D provides an avatar in a virtual world and paves the way for meeting people and participating in individual and/or group activities just like in the real world. Applications such as Second Life and Red Light, which have become very popular in the last few years, are examples of Web 3D. According to the media-centric web approach, in the near future search engines can use elements like audio,
video and images as input. For example, it will be enough to upload a car image to the search engine in order to do a search on cars. Search engines can find similar cars in accordance with the properties of images.

Table 3  Comparison among the Webs

<table>
<thead>
<tr>
<th>Web 1.0</th>
<th>Web 2.0</th>
<th>Web 3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read-only</td>
<td>Read-write</td>
<td>Read-write intelligent</td>
</tr>
<tr>
<td>Static web</td>
<td>interactive web</td>
<td>web</td>
</tr>
<tr>
<td>Company-oriented</td>
<td>Community-oriented</td>
<td>Individually oriented</td>
</tr>
<tr>
<td>Low-portability</td>
<td>Medium portability</td>
<td>High portability (mobile</td>
</tr>
<tr>
<td>(computing equipment)</td>
<td>(mobile)</td>
<td>and consumer electronics</td>
</tr>
<tr>
<td>Professionally developed</td>
<td>User-developed open</td>
<td>User-developed smart</td>
</tr>
<tr>
<td>stand-alone applications</td>
<td>applications</td>
<td>applications</td>
</tr>
<tr>
<td>Syntax-aware basic</td>
<td>Syntax-aware advanced</td>
<td>Content (semantic)-aware</td>
</tr>
<tr>
<td>browsing and search</td>
<td>browsing</td>
<td>and context-aware</td>
</tr>
<tr>
<td>capabilities</td>
<td>and search capabilities</td>
<td>next-generation browsing</td>
</tr>
<tr>
<td>Low data richness</td>
<td>Medium data richness</td>
<td>and search capabilities</td>
</tr>
<tr>
<td>(HTML)</td>
<td>(XML)</td>
<td></td>
</tr>
<tr>
<td>Point-to-point/hub &amp; spoke</td>
<td>Service-oriented architecture</td>
<td>Web oriented</td>
</tr>
<tr>
<td>architecture</td>
<td>(SOA)</td>
<td>architecture (WOA)</td>
</tr>
<tr>
<td>Sliced data</td>
<td>Light interlinked</td>
<td>and internet of things</td>
</tr>
<tr>
<td></td>
<td>data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Worldwide database</td>
<td></td>
</tr>
</tbody>
</table>


Another benefit that Web 3.0 presents to businesses is about decision making processes. Decision making is one of the most important difficulties during management. The amount and quality of existing
information play important roles in decisions that are made at operational, tactical and strategic levels by managers in order to reduce risks. For managers the web has been relatively important as a source of information for years. After the novelties that were brought by Web 1.0 and 2.0, the accessible amount of information has increased, and managers have found it difficult to structure and filter information. With Web 3.0, the paradigm has change from read-only to read-write and current information can be adapted to specific user needs (Naik and Shivalingaiah 2008). In terms of business perspective, Web 3.0 is a significant opportunity to establish new working areas in addition to developing them. Web 3.0 presents a more personified web experience and makes time management more effective. On the other hand, Web 3.0 presents opportunities to businesses to rethink business processes and strategies. It provides important advantages in increasing operational effectiveness and reducing costs.

3.5 Big Data and The Internet of Things

In today’s business world, businesses are exposed to a bombardment of data that have different structures and formats and are fed by different sources. Big data is not a new concept; it is a target that changes according to technological development. With cloud based solutions, data storage costs are reduced and the use of commercial databases is encouraged. Through the NoSQL database and new and active database designs such as Hadoop, which allow sharing work load with many servers while dealing with high volume data, big data sets have become real. By 2012, every day there was 2.5 Exabyte data production and this amount doubles every 40 months. These big and complicated data sets have caused the concept of big data to emerge. Due to uncontrollable growth and diversification of big data, businesses use several techniques and technologies in order to collect, analyze and visualize big data. Analysis techniques include A/B analysis, data mining, sentiment analysis, machine learning, space analysis, simulation, and time series analyses. The following technologies are used: Big Table, Cassandra, Google File System, Hadoop, Apache Hbase, MapReduce, MongoDB and Oracle NoSQL DB. In addition, techniques such as Alterian, TweetReach, NM Incite, Social Mention, SocMetrics and Attensity are used (Altunışık 2015).
The internet is not the only source for big data. Today, data production does not occur via internet use but through sensors, computers and automatized devices in businesses. In addition to interaction between machines and devices, social platforms have considerable impact on the globe. Big data is an expression demonstrating the change of data capture, acquisition and storage. In fact, each individual produces important amounts of digital data every day. E-mail correspondence, surfing on websites, use of online tools, use of social media, online payments, games and many similar activities are recorded digitally and stored in the cloud environment. Due to increasing competition in the business world and customer expectations, businesses prefer to collect more data more frequently. Moreover, the increase in multimedia content also influenced big data to emerge.

Another important factor for development of big data is the phenomenon of relationships between machines without human interaction, called “the internet of things”. With rapidly developing technology, particularly since 2010, new generation computer technologies emerged with concepts such as Smart Systems, Smart Things, Smart Environment, Machine-to-Machine (M2M), Internet of Things, Web of Things, Internet of EveryThing, Web of EveryThing and Pervasive-Ubiquitous computing. Machine-to-Machine (M2M) systems are embedded systems that establish cabled or wireless communication through the internet. Internet of Things uses RFID (Radio Frequency IDentification) technology and communicates with other systems on the internet. It is an embedded system that works with a battery and consumes less energy. Here, things can be any sensor on any physical device. In the Internet of Things, there are machines, things, media, infrastructures and smart machines that communicate and interact. Physical devices and things that make smart decisions interrelatedly on the web are called the Internet of Things. In the Internet of Things, only the interaction of things, devices and machines is present whereas the Internet of EveryThing additionally includes connections between humans and humans and machines. For example, when data acquired from a sensor on a medical device is delivered to a specialist in real time, he immediately takes the action that is necessary for the cure. On the other hand, in the Web of Things, different from the Internet of Things, things communicate by using WEB standards. In the Web of EveryThing,
things, machines and humans communicate with each other with WEB standards. Ubiquitous Computing/Pervasive Computing is a computer concept indicating that a computer can be everywhere and anywhere (Çamurcu et al. 2014).

Businesses have become aware that new data collection and analysis techniques provide opportunities to increase efficiency, rehabilitate decision making processes and gain competitive advantage. The effects of big data are not limited by economic dimensions. Businesses obtain significant advantages through real time information that is provided by big data. For example, big data, which is multidimensional and received in real time, will facilitate smarter management of daily life, traffic jams in cities, interactions between social networks, energy management, e-government applications, data transfer and financial transactions (Altunışık 2015). This situation not only makes businesses more efficient but also positively affects processes within businesses such as decision making, management, innovation and creativity.

4 INNOVATION: THE NEW CHALLENGE FOR BUSINESS
First of all, we need to define the concept of innovation, while discussing the impacts of technology on innovation, which is this article’s topic. A widely recognized description of the concept, on which this study is based, is OECD-Eurostat’s (2005) definition of innovation. Accordingly, innovation is “the implementation of a new or significantly improved product (good or service) or process, a new marketing method or realization of a new organizational method”. Innovation is considered as situations of transfiguration of an unknown or existing product, new production process, new market creation or the finding of a new source concerning raw or semi-manufactured products (Schumpeter 1989). It is sometimes confused with the concept of technology; most of the time innovation is understood as technology. In another definition, innovation is the transformation of an idea to an economically beneficial, marketable, commercial good with the help of science and technology. Therefore, it is not a novelty but a process from a new idea to a new product. World famous management scientist Peter Drucker defines innovation as “a change that creates a new dimension of performance”. Another recognized definition in the literature came from Westland, who defines innovation as togetherness of invention and commercial
achievement (Westland 2008). Another scientist, Trott (2005), defines innovation as “the solution producing process of individual and societal problems by creative individuals, competitive and progressive companies with scientific and technological approaches”. The OECD and European Commission joint publication, the Oslo Manual, classifies innovation under four types.

*Product innovation* is the release of a new or considerably developed/improved (in terms of intended use) good or service to market. This includes significant developments/improvements in technical properties, parts and materials, firmware, ease of use and other functional properties. Particularly the products that are produced in parallel with the rapid development of technology have experienced a fast transformation. Production of innovative products used to take a long time but recently this duration has been shortened.

*Process innovation* is the implementation of new or considerably developed/improved distribution or production methods. This includes considerable changes in techniques, equipment and/or software. Again, process innovation, where business processes have experienced transformation due to technological developments, has gained a different format. The change in ways of doing business has reflected on business processes and technology-intensive processes have gradually increased. Integrated communication technologies, transformations in production lines, and cloud computing technologies have brought different perspectives on mobility process flows and processing.

*Marketing innovation* is the implementation of a new marketing method, which includes considerable changes in product design or packaging, product placement, product promotion or pricing. Especially the rise of digital marketing has brought important transformations in this area. The constant increase of virtual shopping and the access of the masses to products and goods online brought different perspectives and focus to the issue.

*Organizational innovation* is the implementation of a new organizational method in a company’s business practices, workplace organization or external affairs. Organizational innovation is also considerably affected by transformations in technology. Particularly, rapid inclusion of smart systems, specialist systems and learning
organizations into the process has brought a transformation with regard to organizational innovation.

As definitions indicate, innovation for companies necessitates an assessment of a new invention that comes into being in a theoretical framework and in terms of commercial success. From Trott’s (2008) perspective, innovation is an economic process, causing significant increases of objective functions of units such as individuals, companies, states and societies. Innovation is defined as a process of new and significant economic asset creation that increases the welfare and gains of these units and outputs of this process. As a result, innovation in a broad sense can be defined as a new and important economic asset creation process/outcome, which significantly contributes to human welfare.

Today, the most important contribution to these processes is associated with developments in science and technology. Rapid transformation and development of technology makes new products and services possible through new technologies and allows new entrepreneurs who convert these technologies into commercial values. Despite different approaches to define innovation, there is a common view about its importance. The most important factor in a country’s economic development and competitive power is technology. Technological innovation is a mechanism that is used for increasing social welfare and life quality. It is necessary to make economic growth sustainable. The success and competitive power on an international level of developed countries and their nations’ welfare and prosperity depend on their capacity to develop new products and processes and to create constant innovation in order to increase efficiency. Innovation is a tool in the transformation of a society’s resources into products and services and the marketing of them. For this reason, innovation is not only an economic system but also makes technology a social system, which is used on behalf of humans to generate employment and to contribute to environmental protection (Turanlı and Sarıdoğan 2010).

Schumpeter (1939) was one of the first economists to emphasize the importance of new products to keep economic developments in motion and to demonstrate that acceleration of economic growth is a product of technological progress. Schumpeter claims that the competition created by new products is more important than marginal changes in
the production of current products. In addition, it is suggested that modern companies, which are equipped with technology and research and development activities, are central actors of innovation. Other scientists also contributed ideas over the years (Trott 2005). After Nelson Winter’s book “The Evolutionary Theory of Economic Growth” (1982), the term “evolutionary approach” has become popular. In the light of Schumpeter’s work, this approach regards technological innovation as the engine of economic growth in the long run. In evolutionary analysis, the technological innovation process has a central role.

Schumpeter (1934, 1942) talks about two different structures of innovation in terms of companies. He states that in one of these structures, the basic source of innovation is small companies of entrepreneurial spirit that work against severe competition. In another structure, the basic source of innovation is big companies, which have large research and development facilities and work with oligopolistic competition. He suggests that the real competition line of researcher companies is not on the basis of prices, but is about products, processes, and novelties in markets and strategies.

Moreover, entrepreneurs’ achievements of new products and services, new production and transportation methods, new markets and new industrial organizational structures are regarded as central elements of development. As long as the entrepreneurial spirit continues to make achievements, development continues, whereas when the entrepreneurial and innovative spirit finishes, development stops (Heertje 2006). According to Schumpeter, the initial stage of a long economic structure is characterized by creative destruction. In this stage, the basic actors are innovative companies and enterprises. Technological involvement in industry is easy. Innovative and new companies evolve in industry with new innovations and constantly demolish all production, organization and distribution structures of existing companies and capture quasi rent that has been created by former innovations. Smaller companies and pioneer sectors grow mature in the extension phase of the conjecture. Therefore, creative accumulation appears. In this stage, current companies are strong and they provide obstacles to new companies when they enter the industry. Towards the end of the conjuncture, new innovations appear. These create new pioneer sectors and lead previous sectors to reconstruct (Turanlı and Saridoğan 2010).
During the twentieth century innovation was a politics-oriented concept. Since the mid-1960s, with the expected outputs of technological innovation, science policies were mostly concerned with providing funds for scientific research (Godin 2007). In the 1960s this process, which was called science policy, turned into science and technology policy and by the 1990s, it became innovation policy (Lundvall and Barros 2005). In the 2000s, where the process of information revolution was experienced, technology and innovation policies, which were among the important factors in economic growth and competitive power of counties, became gradually more and more important. It is observed that policy makers specially emphasize these issues.

In the literature, there are many indicators on multiple levels demonstrating innovation. Indicators on levels such as country, industry and company are mentioned. For example, on the country level, research and development expenses, export of high technology, industrial added-value, innovation capacity and export of information and communications technology reflect innovation. On the industry level, it is reflected by elements such as development of new manufacturing processes, the appearance of a new research system, new sources of raw materials, advanced production techniques and patent ownership. On the company level, it is emphasized that new or enhanced products and services, new sales approaches, new management styles, financial factors and technological sufficiency are determinants in producing innovation. When these innovation indicators are considered, it is obvious that different technological processes and tools affect innovation.

5 THE ROLE OF TECHNOLOGY IN INNOVATION
As mentioned in the previous sections of the study, a necessity that the business world is faced with in the in the recent period is innovation. In this respect, the main question addressed in this conceptual paper is, “how does technology, which has been undergoing relatively rapid change recently, affect innovation practices in businesses”. Many studies claim that change and development in technology and subsequent innovations do not only cause significant changes on levels of industry and companies but also social, political and social changes. After above-mentioned statements, this part focuses on how technology affects innovation efforts in companies.
There are many empirical studies examining the relationship between technology and innovation in the literature. According to one of these studies, there is a significant and positive relationship between elements of IT focus on technological advancement (e-Commerce) to KM and innovation performance (Gloet and Terziovski 2004). In another research, Huang and Liu (2005) indicated that there is a positive correlation between IT and innovation. Moreover, it was asserted that adopting technology and technological proactivity have a positive effect on innovation (García et al. 2007). In their research, Liu and Buck (2007) concluded that expansion originating from exports and imports is positively associated with the innovation capacities of domestic firms. Koellinger (2008), in turn, examined the relationship between technology, innovation and company performance in a study conducted on 7,302 firms. According to the results of this research, Internet-based technologies were significant promoters of innovation. The research also revealed that both Internet-based and non-Internet-based product and process innovations brought sales and employment increases. Another finding of the research was that innovation was a mediating variable of technological investment performance. In another research, the innovation strategies and performances of low-tech companies were compared with the innovation strategies and performances of medium- and high-tech companies. It is identified that low technology companies’ innovation performance of products and services are behind innovation performance of middle and advanced technology companies (Kirner et al. 2008). Another research conducted on 753 companies addressed technological innovation performances. The impact of low- and medium-tech companies’ efforts to research and generate technological innovation on their innovation performances was investigated. The research identified that innovation performances of companies with low R&D investments were lower (Tsai and Wang 2009). Moreover, it was indicated that technological innovation is employed rather extensively in generating value added and improving performance, and particularly brings achievements and competitive advantage in production (Lee et al. 2009). The researches on technology transfer, integration of technology to the company, and advancement of innovation, in turn, highlighted that unless external technology is combined with the company’s own R&D, it will not be sufficient for innovation (Li and Wu 2010). In a
research conducted on 254 SMEs, the relation between SMEs’ R&D competencies and their technological and innovation performances was examined. The research identified a correlation between companies’ abilities to commercialize their technological products and their R&D and innovation performances (Kim et al. 2011). In a study conducted on employees, on the other hand, the relationship between convenience in utilizing technology, innovation propensity and perceived utility among employees, and the intention to use technology was investigated. The research identified a significant correlation between innovation propensity and the intention to use technology (Farmani et al. 2012). Furthermore, it was understood that the breadth of technological opportunities had a positive impact on innovation. Accordingly, the effects of science and technology parks in Spain on innovation was examined. The research revealed that science and technology parks had a strong and positive impact on companies’ innovation performances (Vásquez et al. 2014). Another research conducted on 175 SMEs investigated the impact of online information sharing on innovation performance. The research identified that information sharing in electronic environment served as a mediator between human resources practices and innovation performance (Acosta et al. 2016).

Researchers, who generally emphasize that technology in an important factor in the production of innovation, identify a significant and positive relationship between technology that is employed in all businesses and business process and innovation. Technology’s positive effect on innovation has been confirmed by empirical studies that are presented in Table 4. Researchers state that technology, innovation and research and development activities are among leading factors that determine growth rates of countries in the long run. Businesses are basic actors of this economic development. They support this development considerably with their research and development and innovation activities. Especially the active use of technology, which has been accompanied by new innovative products, locates businesses in an advantageous position in many ways. Adaptation of technology by businesses in their own structure, their technological proactivity or rapid adaptation to digital technologies positively affects innovation processes. Researchers frequently state that companies that were not able to keep pace with technology achieve success later than others. It is
also assumed that catching up with innovation could be more difficult if businesses are not able to integrate new and different technologies with their development and research activities.

6 DISCUSSION
The previous sections of the study addressed the ongoing transformation in technologies utilized in businesses, organizational processes and business models respectively and elaborately. Even though these issues have been on the agenda of businesses for decades, the rate of the ongoing transformation in these fields has relatively gained pace recently. The main issue at stake here is the rapid transformation in technology. The transformation and renovation of technology at an ever increasing pace is being reflected on the business world, leading to changes in organizational structures, business models and processes. Within this framework, the interesting question according to this paper is to see how these technology-driven transformations affect innovation. It seems possible to provide an answer to this question on the basis of secondary resources which also include empirical findings. For instance, cloud computing, which has rapidly become more of an issue for businesses and the business benefits of which is defined in Table 1, assists businesses of different scales in storing and managing their data in a reliable way by transforming them into information, and hence facilitates information management, which is a major source of innovation. Furthermore, it was revealed that social networks, which have recently become extremely popular among individuals, can also become useful tools for businesses, and may have a positive impact on, for instance, product development and marketing research processes, which in turn lead to innovation. Considering another technology which may be of importance to businesses, Web 3.0, it can be suggested that its properties such as being individually oriented, high probability, user-developed smart applications etc. may make significant contributions to form a basis required by innovation. In view of the fact that innovations do not only originate from employees, but also from customers and consumers today, it appears that effective use of Web 3.0 may serve as a significant input to innovations to be made in products and services.
7 CONCLUSION

Due to technology and its extension, the point we reach today includes a much more rapid development than in previous years. Nowadays in both social life and business life, developments in information technologies make breakthroughs every day. Businesses first used digital transformations in order to enhance their working orders. Then they have spread these transformations to all fields of business and gathered more efficiency and performance. In addition, in connection with new technology use, increase in business performance makes businesses keep technology constantly on the agenda. Therefore, widespread use of new technologies in businesses has become an important factor in innovative products and innovation processes. The rapid change of new technologies and the emergence of innovations at short intervals keep businesses alive and motivate them to look for novelties constantly. These novelties made by businesses in their structures and processes help to reduce costs and increase quality. Due to innovations of products, it is easier to respond to customer needs and demands in a faster and more comprehensive way. Therefore, companies can be more competitive. In today’s conditions, it is not enough to produce goods and services that are only compatible with needs. Innovations within businesses, quests for marketing products or services, novelties in processes, and developments in educating and directing customers about products play important roles in the determination of competition strategies. This situation pushes businesses to present innovative products. The importance of technology in developing innovation becomes more and more prominent. Technologies that are employed in businesses create dynamism. When factors such as intensive interaction, which is made possible through these technologies, a creative atmosphere thanks to the use of technological devices and the increasing tendency of employees and customers to lean towards technology together are taken into consideration, this technological framework constitutes an important base for innovations to emerge.
REFERENCES


The Role of New Technologies in Innovation


**KEY TERMS**

Big data
Business model
Business process
Cloud computing
Innovation
Internet of things
Organizational structure
Social network
Technology
Web 3.0
QUESTIONS FOR FURTHER STUDY
1. Discuss how technology transforms business life.
2. Introduce the basic technologies employed by businesses, and explain how these technologies affect innovation.
3. Explain types of innovation and discuss the relative importance of these innovation types for businesses using arguments.
4. How does technological development affect organizational structures?
5. Do all businesses have to follow technological developments closely? Discuss.
6. While certain industries are so adept in innovation generation, other industries are relatively slow. Discuss.

EXERCISES
Imagine that you are the innovation manager of an automotive plant in a developing country. Which technological tools would you use the most for innovation?

Imagine that you are managing an e-commerce company. How would you use social networks while designing innovations related with your services?

Imagine that you are managing a traditional bakery. What kind of innovations would you introduce in such a bakery?

Imagine you are the general manager of a bank. Which communities would you interact the most in order to innovate?

FURTHER READING


LEARNING OBJECTIVES
The main objectives of this chapter are to present a comprehensive and praxis-oriented approach to efficient usage of modern IT-service management systems in real-world business organizations. After you have mastered the materials in this chapter, you will be able to:

- Discuss professionally the key concepts and technological issues in the domain of modern IT-service management systems (ITSM) and IT-Infrastructure Library (ITIL)
- Identify different ITSM-configurations with respect to specific needs of target business organizations
- Understand how to integrate ITSM-data resources and data models already existing in corporate IT-infrastructure using ontological specifications
- Get familiar with an approach to advanced incident management in ITSM
- Find out the importance of adaptive requirements traceability within the modern DevOps-framework for bridging gap

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between agile software development and ITIL-based IT-service operations

- Have a look at the concrete results of the ITSM test-case project performed at the large technical university.

CHAPTER OUTLINE
An integrated knowledge-based framework to increase efficiency of IT-services management in business organization is proposed, which includes 3 interconnected tasks to be solved: 1) how to choose an effective configuration of ITSM-system (ITSMS) according to specific features and needs in problem domain; 2) in which way to integrate a given ITSMS into existing enterprise architecture; 3) to provide an advanced incidents management for corporative IT-customers. To develop software solutions for all these approaches the agile-centered requirements management was proposed, especially with respect to advanced requirements traceability in Scrum-methodology. All main elaborated methods and software facilities were tested successfully within a proof-of-concept project performed at the National Technical University “Kharkiv Polytechnic Institute” (Ukraine).

KEYWORDS
IT-service, effectiveness, multi-criteria, ontology, precedent, agile-development

1 INTRODUCTION
In last few years the concept of ITIL (IT Infrastructure Library) (Stewart 2013), and correspondently a new kind of information management systems: IT Service Management System (ITSMS) became a prospective platform to solve a complex technical problem and, at the same time, an important business-focused issue: how to organize and to support a well-structured and controllable IT-environment at a target organization?

Currently about 60% of business organizations are using the standards of ITIL to provide their IT-services (Iden and Eikebrokk 2016), while ca. 80% of managers of IT departments argue that ITIL-recommendations significantly increase efficiency of IT-services and reduce the time needed to support IT infrastructure in stable state. Finally, this leads to a reduction in financial costs to ensure reliable
operation of IT-departments approx. from 4% to 2.4% of the total cost of a target business organization.

According to ISO/IEC 20000 (ISO/IEC 20000–1: 2011) an IT Service Management System (ITSMS) provides “…a framework to enable the effective management and implementation of all IT-services”. Due to highly complex and multi-dimensional structure of IT-services in modern business organizations, where ITSMS are used, a lot of publications in this problem domain present different approaches how to develop and to handle these facilities. One such important topic in ITIL-ITSMS domain is an integration of ITSMS functionality into already existing enterprise business architecture (see, e.g. in (Braun and Winter 2007)). Another recent trend in ITSMS-development is the usage of ontology-based models and model-driven architectures (MDA) (Valiente et al. 2011, 2012) in order to handle domain knowledge and to reuse software components. It also is to mention an actual need to elaborate some agile- approaches to requirements engineering within the ITSMS-development framework (see e.g. in (Lichtenberger 2014)).

Taking into account some ITSMS-issues mentioned above, the main goal of this contribution is to propose a complex approach to increase an efficiency of ITSMS usage, with a proof of concept based on the IT-infrastructure university case-study.

2 ITSM SYSTEM TYPICAL FUNCTIONALITY AND A COMPLEX APPROACH TO INCREASE EFFICIENCY OF ITS USAGE IN TARGET BUSINESS ORGANIZATION

In order to elaborate a way how to provide a complex approach to increase the efficiency of ITSM-system operating, it is necessary to analyze critically its typical functionality and to understand its specific features.

2.1 Classification and overview of some existing ITSM systems

We have analyzed some already existing ITSMs, and actually, taking into account their specific functional features and approaches used for their implementation, all such systems can be divided into 3 groups, namely (Tkachuk et al. 2013):

- a) advanced business ITSM-products,
- b) open-source ITSM-solutions,
c) company-oriented individual ITSM-systems.

To the group (a) belong such systems as, e.g., HP OpenView Service Desk, and BMC Remedy. The first software product is the absolutely leader in this market segment, because the most part of organizations which prefer ITSM-business solutions from the group (a), are using exactly HP-platform. The number of installations running the second product is less than for HP, at least because of more expensive costs of Remedy ITSM Suite. For our purpose: to understand and to analyze critically a typical ITSMS-functionality, exactly such this product-group is important, and their main options are (Tkachuk et al. 2013):

- an enhanced data modeling toolkit that enables to identify all necessary informational attributes for domain modeling elements and relationships between them;
- a workflow-editor which allows to describe business processes running in a target organization, their possible changes and requests for IT- services needed for customers;
- an advanced data visualization;
- a special facility to analyze the mutual influence of changes that occur in different IT-services configurations, which helps to prevent conflicts in their development.

Besides that, the typical features of these systems are the following:

- access via Web-interfaces;
- high degree of system scalability due to the possibility for installation with distributed business logic processing on several application servers and with data synchronization using appropriate backup/restore and data replication procedures;
- availability of full system documentation suite, including a description of all key processes and their relationships, procedures, roles using RACI (Responsibility-Accountable-Consult before-Informed) matrix.

The summarized results of this study (Tkachuk et al. 2013) are presented in the Table 1 (where the marks from 1 to 5 are used for excellence estimation).
Table 1  Results of comparison of some ITSMS

<table>
<thead>
<tr>
<th>Criteria/Systems</th>
<th>BMC Remedy Suite 7.5</th>
<th>Axios Assyst 7.5</th>
<th>HP Service Manager 7.10</th>
<th>OMNINET OmniTracker ITSM Center 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic functionality</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Maintainability</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Documentation suite</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Scaleability</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Web-interface</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

ITSMS-solutions from the group (b) also are used in practice, but they definitely have limited functionality and provide a lower level of IT-services management. The typical open source ITSMS are, for instance, OTRS (OTRS.com 2016), and some others, which are listed at the Web-resource SourceForge (SourceForge.net 2016).

And, objectively, the business organizations, which are not ready to buy advanced software products from group (a), and which are not satisfied with functionality provided by ITSM-systems from group (b), try to develop their own ITSM-solutions to be considered as members of the group (c). The more detailed study of some existing ITSM-systems is presented in (Tkachuk et al. 2013).

2.2  Typical ITSMS-functionality and its shortcomings

Based on the given analysis of some ITSMS (see above), we propose the following vision for their typical functionality shown in Fig. 1 as the UML-diagram (UML.org 2016).
There are 5 main subsystems (or packages) of system functions, namely:

1. *IT Business Alignment*: this subsystem is supposed to implement a IT-strategy in given business organization with respect to its main goals and needs, and to provide a base for costs assessment to whole IT-infrastructure;

2. *Service Operations*: this facility is responsible for customer’s requests management (regarding to a current incident and to a related problem), and for providing of ITSM-support functions;

3. *Service Delivery Assurance*: this functional package implements a configuration and change management of all ITSM-software tools thus is extremely important for a stable IT-environment;

4. *Service Design and Management*: this ITSMS-functionality provides detailed information about new perspective IT-services to be designed with respect to their availability and quality for IT-customers;

5. *Service Development and Deployment*: this subsystem allows to create and to test new ITSM-services and appropriate IT-infrastructure solutions, including installation of new hardware.
components, development of additional software applications, and training programs for ITSM-staff and for end-users as well.

As we can see on the structure presented in Fig. 1, each of these 5 subsystems is built from several functional modules (they are depicted as UML-classes). The most important of them are the following ones (they are labeled in Fig. 1 accordingly):

- **Module M1** = "Incident and service request management": it includes organizational procedures and appropriate tools to resolve current incidents, which IT-service users are facing with (hard-and software errors, network connection problems, request for consultations, etc.);
- **Module M2** = "Problem management": this facility provides tools to detect and to eliminate any problem situation which is a reason for different incidents;
- **Module M3** = "Configuration management": this module supports all operating sub-schemes in the IT-infrastructure of given business organization;
- **Module M4** = "Change management": it supervises and coordinates all changes which arise in IT-infrastructure;
- **Module M5** = "Service level management": this unit is responsible for definition and implementation of an appropriate level of IT-services to be provided for customers.

In ITIL-best practice manuals (e.g. see in (Cleverics.ru 2016)) the following 3 main schemes are considered to introduce these modules into IT-infrastructure of a target organization: a classic scheme (S1); a contract scheme (S2); an infrastructure-centered scheme (S3).

A classic scheme S1 is the most applied solution in the ITSM-domain, and it supposes the following sequence of modules M1-M5:

\[
S1 = (M1, M3, M4, M2, M5) \tag{1}
\]

This approach quickly allows to resolve the most actual communication problems between IT-service department and customers basing on incident management (module M1), and it provides some tools for all
IT-services support (the modules $M_3$ and $M_4$), and after that a platform for future IT-infrastructure development is introduced (modules $M_2$ and $M_5$ respectively). However this scheme is a most expensive way for a given business organization, and it requires a lot of resources exactly at an initial phase of whole ITSM-configuring framework.

A *contract scheme* $S_2$ actually aims to formalize a communication process between IT-service department and customers, and it has the following modules-workflow:

$$S_2 = (M_5, M_3, M_1, M_4, M_2)$$

(2)

In this case all customer requirements to IT-services have to be collected and specified (in module $M_5$), and appropriate IT-infrastructure sub-schemes can be built (using module $M_3$), in order to define prospective IT-strategy in the target organization, next an operative ITSM-functionality is provided, including incident management (in module $M_1$), change management (in module $M_4$), and problem management (in module $M_2$). Obviously, this scheme definitely has some risk factors regarding its efficiency, if the initial IT-service specifications were done not correctly (in module $M_5$).

And, finally, an *infrastructure-centered scheme* $S_3$ proposes the sequence of modules indicated as following:

$$S_3 = (M_3, M_4, M_2, M_1, M_5)$$

(3)

firstly, to provide tools for all IT-services support (the modules $M_3$ and $M_4$ respectively). Secondly, this approach allows to manage all typical problem situations (in module $M_2$), and already based on this one to detect and to resolve corresponding incidents by IT-service customers (in module $M_1$). Thirdly, it creates an opportunity to define in computer-aided way the necessary composition and the IT-service level management (in module $M_5$).

It is necessary to note that besides some empirical recommendations concerning the possible ITSM-modules configurations defined as (1)-(3), in the appropriate technical documentation there are no more or less proved suggestions about possible quantitative estimations for effectiveness of these alternative approaches.
2.3 Complex approach to increase of ITSM-system efficiency

Taking into account the results of the analysis (see above), and based on some modern trends in the domain of ITSMS-development (see Section 1), the following list of prioritized problems can be composed in order to increase ITSMS-efficiency, namely (Tkachuk et al. 2013)

i. to provide an effective configuring of ITSM-modules for a target organization, taking into account its specific features and needs;
ii. to elaborate an integration framework for a given ITSM-system's configuration and for an existing enterprise architecture (EA);
iii. to support an advanced incidents management in the already installed ITSM-system.

In our opinion, the problem (I) can be resolved basing on some expert methods for multi-criteria ranking, e.g. Analytic Hierarchy Process (AHP) proposed by T. Saaty (Saaty 2000), with respect to specific IT-infrastructure’s features and customer needs in a concerned business organization. The problem (II) belongs to already well-known integration issues in distributed heterogeneous information systems, and e.g. an ontology-based approach can be used for this purpose (see in (Valiente et al. 2012)). And, finally, to solve the problem (III) an additional decision-making functionality for typical ITSM-services (see Fig. 1) has to be elaborated, e.g. based on the combination of case-based reasoning (CBR) approach with ontologies (Prentzas and Hatzilygeroudis 2009), (Lopez-Fernandez et al. 2011). Below these problems and their possible solutions are presented and discussed in more details.

3 METHOD FOR EFFECTIVENESS ESTIMATION OF ALTERNATIVE ITSMS-CONFIGURATIONS

To formalize the problem (I) from their list considered in the Section 2.3, namely: to provide an effective configuring of ITSM-modules for a target business organization, the following factors have to be taken into account

• such a problem has a high complexity grade and it is semi-formalized;
• estimation criteria for it are of different nature and they are multi-valued;
• an information base to solve this task mainly can be collected basing on expert data;
• an available expert data could be quantitative and qualitative values both.

To solve this problem we have chosen one of the multi-criteria ranking methods, which is presented in (Tkachuk et al. 2013). Accordingly to this approach the following steps have to be performed:

Step 1. A set of possible alternatives,

\[ X = \{x_1, x_2, \ldots, x_n\} = \{x_i, i = 1, n\} \]  

(4)

and a set of global importance criteria to characterize these alternatives

\[ K = \{K_1, K_2, \ldots, K_m\} = \{K_j, j = 1, m\} \]  

(5)

have to be defined. In our case as such alternatives the possible configurations of ITSMS-modules should be considered (see in 2.2 above).

Step 2. Each global criteria \( K_j \) is characterized by a subset of appropriate local criteria (see the example of their possible definitions and values given in Section 6, in Table 5 and Table 6 respectively)

\[ K_j = \{k_{j1}, k_{j2}, \ldots, k_{jQ}\} = \{k_{jq}, q = 1, Q\}, \]  

(6)

further, a set of membership functions according to all local criteria alternatives

\[ \{\varphi_{k_{j1}}(x_i), \varphi_{k_{j2}}(x_i), \ldots, \varphi_{k_{jq}}(x_i)\} = \{\varphi_{k_{jq}}(x_i), q = 1, Q, j = 1, m\}, \]  

(7)

and the weight coefficients of their relative importance for these local criteria

\[ \{w_{j1}, w_{j2}, \ldots, w_{jq}\} = \{w_{jq}, q = 1, Q\} \]  

(8)
have to be determined, e.g., using pair-wise comparison in AHP method (Saaty 2000), where the following condition (9) has to be fulfilled.

\[ \sum_{q=1}^{Q} w_q = 1 \]  

(9)

Step 3. To determine membership functions of alternatives \( \{x_i, i = 1, n\} \) to criteria \( K_j, \{j = 1, m\} \) based on an additive convolution of their local criteria

\[ \varphi_{k_j}(x_i) = \sum_{q=1}^{Q} w_{jq} \varphi_{kjq}(x_i) \]  

(10)

Table 2: Definition of membership functions for criteria to alternatives (fragment).

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Criteria K</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K_1</td>
</tr>
<tr>
<td>X</td>
<td>x_1</td>
</tr>
<tr>
<td></td>
<td>\varphi_{k11}(x_1)</td>
</tr>
</tbody>
</table>

Step 4. Taking into account the membership functions obtained \( \{\varphi_{k_j}(x_i), j = 1, m\} \) for all alternatives \( x_i, \{i = 1, n\} \) it is possible to determine a joined membership function for a generalized criterion \( K \):

\[ \varphi_K(x_i) = \sum_{j=1}^{m} w_j \varphi_{K_j}(x_i) \]  

(11)

where \( w_j, j = 1, m \) are coefficients of their relative importance \( K_j, j = 1, m \).
Step 5. Finally, an alternative with a maximum value of membership function for generalized criterion $K$ can be chosen as a target solution:

$$\varphi(x^*) = \max \{\varphi_k(x_i), i = 1, n\}$$  \hspace{1cm} (12)

Below in Section 7 we present the complex case-study which was performed to prove this method, and we discuss the results achieved.

4 ONTOLOGICAL SPECIFICATIONS FOR ITSMS-EA DATA INTEGRATION FRAMEWORK

As already mentioned above (see Section 2.3), any ITSMS has to be integrated into an existing EA of a target organization. In our approach this problem (II) has to be resolved for an ITSMS-configuration defined with the method presented in Section 3.

To provide ITSM-EA data integration effectively, it is necessary to combine the following information resources (IR), namely (Tkachuk et al. 2013)

a) IR that is related to ITSMS—functionality,

b) IR that describes EA-domain, and

c) IR that characterizes a target organization (TO), which is facing an ITSMS-EA integration problem with.

As already mentioned below (see Section 2.3), we propose to use the ontology-based approach to integration of different IR, and respectively we have defined a collection of logically interconnected ontologies as an ontological specification of an appropriate IR. Let’s designate these ontological specification for IR given in (a)-(c) as: Onto-ITSMS, Onto-EA, and Onto-TO respectively. Thus, the IR needed to provide an ITSMS-EA integration should be specified using an appropriate joined ontology, designated as Onto_ITSMS-EA.

$$\text{Onto}_{-}\text{ITSMS} - \text{EA} \leq< \text{Onto} - \text{ITSMS}, \text{Onto} - \text{EA}, \text{Onto} - \text{TO} >$$  \hspace{1cm} (13)

Obviously, some already existing ITIL/ITSM ontological specifications can be used for this purpose, e.g.: Onto-ITIL ontology elaborated in (Valiente et al. 2011), Onto-SPEM (Software Process Engineering Meta-model) ontology (Rodriguez-Garcia et al. 2010), and Onto-WF (WorkFlow) ontology (Prieto and Lozano-Tello 2009). Taking these
resources into account, we can represent the ontological specification for Onto_ITSM in the following way.

\[ Onto – ITSMS =< Onto – ITIL, Onto – SPEM, Onto – WF > \]  

(14)

There are also several ontologies developed to specify EA, and according to one of comprehensive researches in this domain presented in (Kang et al. 2010), we accept the following 3-level definition for EA-ontology.

\[ Onto – EA =< Onto – BT, Onto – AC, Onto – RS > \]  

(15)

where: Onto_BT is a sub-ontology of Business Terms (BT), Onto-AC is a sub-ontology of Architecture Components (AC), and Onto-RS as a sub-ontology of RelationShips (RS) among items of AC.

And finally, to define an Onto-TO ontology for target organization given in expression (13), its specific features and needs related to ITSMS-usage within existing EA have to be taken into account. As a small excerpt of such domain-specific Onto-TO, which is elaborated in our University ITSMS case-study (see Section 7), the following UML-class diagram in Fig. 2 is shown. It represents the taxonomy of ITSMS-users, taking into account the availability of their various categories, including local administrators of network resources (servers), such as:

- LAN administrator,
- DB server administrator, and
- Web server administrator.

In addition, this ontological specification (Fig. 2.2) also defines two classes of IT-service end-users, namely:

- university regular user (stuff member), and
- visitor (temporary users),

and the first of their category, in turn, is divided into three sub-categories: staff members of departments that conduct training of IT-specialists, staff of technical departments, and staff members of the department of humanities.
The proposed ontological specifications (13)—(15) for ITSMS-EA data integration can be processed with the appropriate algorithm that is discussed more detailed with test-case example in Section 7.

5 ADAPTIVE ONTO-CBR APPROACH TO ADVANCED INCIDENTS MANAGEMENT IN ITSM

In order to solve the problem (III), namely: to provide an advanced incidents management in ITSMS, accordingly to our inter-disciplinary vision about the ITSMS-development in general, we propose to amalgamate the following design tasks (i)-(iv) listed below (Tkachuk et al. 2013)

i. an incident management as a weak-formalized and complex task within the ITSMS-support for its customers can effective be resolved using one of the intelligent decision-support methods, e. g., using CBR-method;

ii. to enhance a CBR-functionality, especially with respect to specific needs in a target organization, an appropriate domain-ontology should be elaborated and used combining with CBR;
iii. because of permanent changes in an IT-infrastructure of a given organization, and in its environment as well, such a domain-ontology has to be constructed as an *adaptive ontology*.

As mentioned above, there are already some approaches elaborated to combine a CBR-method with ontologies (Prentzas and Hatzilygeroudis 2009), that allow to provide case-representation more efficiently, to enhance case-similarity assessment, and to perform case-adaptation process for a new solution. These approaches provide solutions for the tasks (i)-(ii), but in our opinion, to cover the task (iii) in more efficient way, with respect to permanent changes in IT-infrastructure of a target organization, an appropriate ontology has to be constructed as *adaptive* facility (Tkachuk et al. 2013). Thus the *Onto-TO* ontology given in Section 4 should be given as the following tuple

\[
\text{Onto} - \text{TO}^{\text{(adapt)}} = \langle C, R, P, W^{(C)}, W^{(R)} \rangle
\]  

(16)

where, additionally to the basic components of any ontology, namely: 
- \( C \) is set of concepts,
- \( R \) is a set of relationships among these concepts,
- \( P \) is a set of axioms (semantic rules), and the following ones have to be defined: 
  - \( W^{(C)} \) is a set of weight coefficients for concepts of \( C \), and 
  - \( W^{(R)} \) is a set of weight coefficients for relationships of \( R \) respectively.

Usage of these weight coefficients allows us, e.g., to take into account an appropriate importance grade in several types of ITSMS-customers (see Fig. 2) to provide IM - services for them.

Each precedent \( C_i \) has to be presented in the system knowledge base using the following tuple (Sokol Vlad. 2014)

\[
C_i = \langle ID, H, P, S \rangle
\]

(17)

where \( ID \) is a unique identifier, \( H \) is a header of this precedent (as a text), \( P \) is a problem description (as a text), and \( S \) is an appropriate solution for this problem (as a text). The example for such description is presented in Table 3.
Further, to process all these text specifications $H$, $P$ and $S$ in a search algorithm to find for appropriate problem the corresponding solutions a set of some key words (KW) has to be used (Sokol Vlad. 2014). Each such a KW belong to one predefined category, namely: KW “IMS” belongs to category item “Dept (Department)”, “MS Windows 7” to category item “OS (operating system)”, etc. It is to noted, that the inion set of all categories and all KW is a set a set of concepts $C$ from the formula (16), which defines the appropriate adaptive ontology $Onto-TO$. Besides that using a set of weight coefficients for concepts (set $W_{\text{IC}}$ in formula (16)) it is possible to take into account a semantic value (or relevance) of each KW in search of target precedent. Thus we can construct a vector of KW which should be used for a target precedent as following

$$\{(k_{i1}, w_1), (k_{i2}, w_2), \ldots, (k_{im}, w_m)\}, i = 1,2,\ldots, n$$  \hspace{1cm} (18)

where $k_{ij}$ is a j-th KW for a i-th precedent, $w$ is a weigh coefficient for this KW, $n$ is a number of KW, and $m$ is a number of precedents in system knowledge base (see the example in Tabl.3).

Basing on definitions (16) - (18) in the search algorithm 2 vectors of KW can be formed (see in (Sokol Vlad. 2014) for more details): 1) vector , which represents the current problem arisen by any end-user of corporative ITSMS, and vector which describes any precedent already placed in system knowledge base. Finally, the following similarity metric can be calculated to estimate an appropriate search result

Table 3 Precedent data in system knowledge base (fragment)

<table>
<thead>
<tr>
<th>ID</th>
<th>Header</th>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>“Plugin Git Source Control Provider”</td>
<td>When updating software MS Visual Studio 2014 at IMS Dept failed to install plugin Git Source Control Provider. The following message was received: “Plugin Git Source Control Provider does not satisfy the requirements of the OS”</td>
<td>Update OS MS Windows 7 with SP3 package and try again to install the plugin “Git Source Control Provider”</td>
</tr>
<tr>
<td>2</td>
<td>......</td>
<td>......</td>
<td>......</td>
</tr>
</tbody>
</table>
\[ \text{SIM}(C', C^*) = \alpha \times \text{SIM}_H(C', C^*) + \beta \times \text{SIM}_P(C', C^*) \] (19)

where \( \text{SIM}() \) is a similarity function, \( \alpha \) and \( \beta \) are weight coefficients for similarity of \( H \) and \( P \) descriptions respectively, and \( \alpha + \beta = 1 \).

The example how to use this approach in praxis is shown in Section 7, where we present the real case-study done within our research and practice activities to apply ITSMS for IT-infrastructure management at the National Technical University “Kharkiv Polytechnic Institute” (URL: www.kpi.kharkov.ua) referred in following as NTU “KhPI”.

6 AGILE REQUIREMENTS MANAGEMENT FOR EFFICIENT ITSM-SOFTWARE DEVELOPMENT AND OPERATIONS (DEVOPS)

All ITSMS-issues related with its efficient usage in a target business organization supposes to develop and to operate appropriate software solutions, which are needed to support additional system functionality, to satisfy end-user needs, etc. From the other hand if we are talking about some IT-business organization, which is dealing with software production for third-party companies, its software processes should take into account the existence of ITSMS-environment in this organization.

These two reasons led to the problem how to combine ITIL/ITSMS principles and technologies with such modern agile-software development (ASD) methods like Scrum, Kanban, and some others (Stellman and Greene 2014). One possible approach to solve this issue is presented in the paragraphs below, which are completed basing on some our results in the domain of knowledge-based methods and technological solution for software development and maintenance (Tkachuk et al. 2004), (Tkachuk et al. 2012), (Gamzayev 2013).

6.1 DevOps Approach to Bridging the Gap between Agile-Software Development and ITIL-based IT-Service Operations

The basic contradiction between usage of ITIL/ITSMS-framework and ASD-methods in a target organization is that first one aims to provide stability and reliability of corporative operating environment, while the second one supposes to perform any software project as a flexible sequence of small iterations with respect to permanent changes in customer’s requirements.
To leverage this critical issue in business organizations the so-called DevOps ("Development & Operations") approach is proposed for few last years. According to (Mueller 2010) its main goal is to organize a close and regular collaboration and communication between software developers, QA—engineers, and other IT-professionals, who are responsible for deployment, testing and operating of new software products relies. This main idea of DevOps is shown in form of Wenn-diagram in Fig. 3 (to compare with figure given in (Johnson 2016)). In this representation the following essential feature of such interplaying framework is emphasizing: on each of given activity domains, namely Development, IT-Service operations, and QA-domain some requirements are generated and have to be processed. Because these requirements have the different nature, they are shown graphically as different multiplicity icons: rectangles, triangles, and printing pages. We are deeply convinced that, in order to get success by usage of DevOps approach in any application domain, it is necessary to provide effective requirements traceability in and between all these project activities.

Fig. 3 Conceptual scheme of DebOps approach w.r.t. requirements traceability issues

That is why in this section we consider the models and tools for effectiveness increasing of requirements traceability in ASD (Tkachuk
et al. 2012), (Gamzayev 2013), especially, with respect to such widely used agile-methodology as Scrum (Stellman and Greene 2014).

6.2 Advanced Scrum-method operation scheme: Cybernetic-centered vision

Basically, ASD implies refusal from complete bureaucratic documentation, but really needs support for automated classification of knowledge, in order to reduce the time for adaptation to requirements changes and to minimize risks related to them. Exactly because of these reasons some process control methods called also as “software cybernetics” (e.g. in (Miller 2006)) are used in modern software engineering. On Fig. 4 the cybernetics-centered scheme is shown (Tkachuk et al. 2012), which represent one of the most widespread ASD-methodology, namely Scrum method. There are 2 feedback loops included in this control scheme: 1) daily process control, basing on sprint backlog (SB) and using some source code quality metrics, 2) iteration process control, basing on product backlog (PB) and using some requirements quality metrics. The SB and PB both collect the selected requirements to be met in final software product. In the control loop (1) usually some IDE, e.g. Eclipse is used by developers team, while in the control loop (2) an appropriate requirements management system (RMS) can be exploited by stakeholders (product owners in Scrum) and by domain analysts.

Therefore it is clear that in order to organize a close cooperation between all projects participants (as it is mentioned in 6.1) on the conceptual level, and to support them in computerized way we need: (a) to reflect permanently all requirements changes in source code through an efficient traceability procedure, (b) to elaborate an appropriate CASE-tool which combines integrated development environment (IDE) and RMS functionality both.
To solve this problem it is necessary to trace not only requirements changes and refinements but also to trace requirements to all relevant project artifacts (including source code). Many traceability models and techniques were proposed for this purpose, but the most widespread is a traceability matrix (Ramesh and Jarke 2001). That is why we propose to construct so-called *advanced traceability matrix* (ATM), which allows us to take into account all developers activities in time-oriented data model, with respect to project tasks context and to developer’s roles (Gamzayev 2013). This matrix can be considered as special “control unit”, which is included into the feedback control loop (2) shown in Fig. 4.

### 6.3 Task-focused user interface, DOI-function, and advanced traceability matrix

Next important issue in our approach to agile requirement management is a model of task-focused user (software developer) interface. It is a type of a user interface which hides entire hierarchies of information, such as a file-system tree, and it shows only necessary subset of the tree that is relevant to the active developer’s task. The task-focused interface contains a mechanism which allows developer to specify the task being worked on and to switch between active tasks, a model of the task context such as a degree-of-interest (DOI) function: a focusing mechanism to filter or highlight the relevant projects artifacts (files) related to this task. The first implementation of the task-focused...
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Interface based on DOI-function was started as an open source project called Mylar (Kersten and Murphy 2005) (this facility for IDE Eclipse is now called as Mylin), where the interaction history model was used, but in this case the appropriate DOI-values were calculated only basing on retrospective data about previous developer’s experience.

In order to improve Mylar/Mylin-DOI approach we propose to elaborate the ATM matrix (Tkachuk et al. 2012), which can be built automatically using data gathered from different sources like IDE instances, requirement management system (RMS), and other tools such as version control systems, issue tracking systems, etc. This ATM matrix is defined as follows

\[ M : (R \times F \rightarrow [0,1]) \]  

(20)

where \( R \) is the set of all requirements, and \( F \) is a set of project’s artifacts (files, components, test-cases, bug reports, etc.).

One of the possible ways to define ATM matrix’s values is to take into account a fact, that some files demand more time when working on some requirement. Using such time-oriented metric we can distinguish between small cosmetic change and deep re-design and mark files with small changes as unimportant. The degree of relationship between the file and the requirement can be calculated using the following metric (Tkachuk et al. 2012)

\[ m_{rf} = \sum_{k=1}^{\lvert A_r \rvert} \sum_{j=1}^{\lvert F \rvert} \frac{(t^{(2)}_{f_j} - t^{(1)}_{f_j})}{(t^{(2)}_{a_k} - t^{(1)}_{a_k})}, r \in R, f \in F, \]  

(21)

where \( A_r \) — set of activities related to requirement \( r \), \( F_a \) — set of artifacts changed by activity \( a \), \( t^{(1)}_{Ark} \) — start time of activity \( Ark \), \( t^{(2)}_{Ark} \) — end time of activity \( Ark \), \( t^{(i,1)}_{f} \) — time of \( i \)-th activation of file \( f \), \( t^{(i,2)}_{f} \) — time of \( i \)-th deactivation of file \( f \). Graphical interpretation of this metric is shown on Fig. 5.
Of course, this time-oriented metric has some drawbacks, e.g. it cannot deal with situation when some file was opened, but no work was actually done with it by an appropriate developer.

From the other side, the proposed traceability matrix ATM actually is an aggregation of data about the links between requirements and project artifacts, and for this purpose these data must be quickly and accurately processed. That is why we need to elaborate a special CASE-tool that should allow to gather the appropriate data in run-time mode, and this facility has to be integrated into IDE used by all developers in a target Scrum-project.

### 6.4 Test-case: Software CASE-tool, input data and results analysis

To perform a proof-of-concept project for the proposed approach to agile requirements traceability, we have elaborated a CASE-tool named ReqMIT (Requirements Management Integrated Tool) (Gamzayev 2013). It is integrated into IDE Eclipse, and it is able to gather retrospective data and to support in project’s files when requirements are changed. On Fig. 6.4 the designed system architecture is presented, it is service-oriented to allow any future extension of current solution to add more features in future. Basic RMS features, such as CRUD (Create-Read-Update-Delete) are built-in in ReqMIT system (see in (Gamzayev 2013) for more details). This allows us to perform test on requirements traceability without dealing with other aspects of requirements management. UML deployment diagram of the elaborated software is shown on Fig. 6.
For implementation of message-driven architecture we use the integration framework Apache Camel (Ibsen 2010). It is an open cross-platform Java framework that supports application integration in a simple way, and it is able to work over multiple transport protocols. Besides that we used JMS specification and its implementation Apache ActiveMQ to provide a scalable and reliable messaging mode. As a database facility Java/XML DBMS eXist is used, because all event messages in the system are transformed in XML format.

To provide the efficiency measurement of our approach we have used well-known information-retrieval metrics precision $p$ and recall $r$. These values can be calculated with formulas (Olson and Delen 2008)

$$p = \frac{tp}{tp + fp}; r = \frac{tp}{tp + fn};$$

(22)

where $tp$ is a number of true positive values, treated as interested and used; $fp$ is a number of false positive values, treated as interested but not used; $fn$ is a number of false negative values, treated as not interested, but used in fact.

In Fig. 7 for the test case with 10 requirements the example of appropriate result data are presented: (a) values of $tp$, $fp$ and $fn$ parameters, (b) values of $p$ and $r$ metrics, their average values are 0.43 and 0.61 respectively.
Our main hypothesis is that the proposed approach improves a requirements traceability process by increasing the number of project iterations, because it allows to collect more significant volume of retrospective data in the system database (see Fig. 6). To validate this assumption we have calculated parameters $p$ and $r$ during 40 project iterations, and these data are shown in Fig. 8.

According to (Gamzayev 2013), and to results presented above, ReqMit usage and Agile practice implementation give possibility to identify the following file sets for every task in the ITSM integration process:

- very interesting files or “landmarks”,
- directly interesting files,
• indirectly interesting (or related) files,
• uninteresting (or rarely used) files.

After this each developer can get access to the appropriate collection of selected files in the IDE using the tree-view presentation. Also the different colors or font styles could be used to mark most interesting files related with individual focused task-interface etc.

7 COMPLEX TEST - CASE TO PROVE THE PROPOSED APPROACH
It is to mention that exactly university- and/or a campus-domains are considered by many authors as a suitable example of ITSMS-usage, see e.g. in (Boursas and Hommel 2006), (Knittl and Hommel 2007), because intensive research- and educational activities require a modern and well-organized IT-environment. That is why we also proved our approach using the test-case data collected at the NTU “KhPI”.

7.1 Application domain description: IT-infrastructure of NTU “KhPI”
The NTU “KhPI” is one of the largest technical universities of Ukraine located in the city of Kharkiv, which is the important industrial and cultural center at the East of the country. The University has about 20000 students, ca. 3500 of faculty members, and accordingly there is the advanced IT-infrastructure to support all educational and research tasks. Its simplified topology is depicted in Fig. 9, and some characteristics are given in Table 4.

The daily IT-services provided for faculty members and students included all aspects of IT-technologies, which can be divided into following categories:

• Office automation and desktop applications;
• Wireless network communication;
• University Web-portal;
• E-learning and some others.
In cooperation with the IT-staff at the University IT control office we have analyzed retrospective data about some typical problem situations which have occurred, and about the corresponded incidents, which daily have been resolved within the direct communication with IT-service customers.
Table 4  Some technical data about IT-infrastructure of NTU “KhPI”.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCs in the network configuration</td>
<td>1525</td>
</tr>
<tr>
<td>User’s accounts</td>
<td>2725</td>
</tr>
<tr>
<td>Buildings</td>
<td>23</td>
</tr>
<tr>
<td>Servers</td>
<td>62</td>
</tr>
<tr>
<td>Routers</td>
<td>84</td>
</tr>
<tr>
<td>Peripheral units (ca.)</td>
<td>6200</td>
</tr>
</tbody>
</table>

In this way the main types of ITSM-incidents and their initial problem situations were identified, and they are described in Table 5. Basing on the analysis results obtained, we can apply the elaborated method to estimate alternative ITSMS-module configurations.

7.2 Effective Configuring of ITSM-Modules
According to the Step 1 of the method presented in Section 3, the list of alternative ITSM-module configurations has to be completed, and in our case they are following:

- \( X_1 = \text{Service Desk subsystem (SDS) and Incident Management Module} \);
- \( X_2 = \text{SDS, Incident Management Module and Configuration Management Module} \);
- \( X_3 = \text{SDS, Incident Management Module and Change Management Module} \);
- \( X_4 = \text{SDS, Incident Management Module and Problem Management Module} \).
Table 5  Main types of ITSM-incidents and their related problem situations.

<table>
<thead>
<tr>
<th>№</th>
<th>Incident type</th>
<th>Cause (problem situation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Internet-connection at Dept or on local PC</td>
<td>- router was turned off;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- network cable is braked or failure on router hardware;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- incorrect network setup;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- problems with software on local PC</td>
</tr>
<tr>
<td>2</td>
<td>High-loading of PC processor with a small number of active user’s</td>
<td>- computer viruses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- high degree of PC hard drive de-fragmentation.</td>
</tr>
<tr>
<td></td>
<td>new software</td>
<td>- absence of additional (middleware) software needed for installation.</td>
</tr>
<tr>
<td>3</td>
<td>Installing problems for new software</td>
<td>- computer viruses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- absence of additional (middleware) software needed for installation.</td>
</tr>
<tr>
<td>4</td>
<td>Failure to send email</td>
<td>- incorrect setup of local network server (proxy)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- problems with central e-mail server.</td>
</tr>
<tr>
<td>5</td>
<td>Troubles in the use of third-party software</td>
<td>- lack of specific configuration,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- improper use of system services.</td>
</tr>
</tbody>
</table>

On the next Step 2, according to the formulas (10) - (12), we determine the criteria for the quantitative evaluation of the proposed alternatives and their performance indicators, which are shown in Table.6.

Table 6  List of values for global and local criteria.

<table>
<thead>
<tr>
<th>Global and local criteria</th>
<th>Semantics performance measurement criteria and target values</th>
<th>Insecure values</th>
<th>Effect. values</th>
<th>Possible values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K_1$</td>
<td>Effectiveness of incident management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$k_{11}$</td>
<td>Average time incident resolution → minimum (min)</td>
<td>&gt;30 min</td>
<td>20 min</td>
<td>9999 minutes</td>
</tr>
</tbody>
</table>
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| $k_{12}$ | Percentage of incidents resolved proactively $\rightarrow$ maximum (max) | 0% | 15% | 0–100% |
| $k_{13}$ | Percentage of incidents resolved at the first level of support $\rightarrow$ max | <65% | 85% | 100% |
| $k_{14}$ | Percentage of incidents that have been resolved from the first time $\rightarrow$ max | <75% | 90% | 100% |

$K_2$ | Effectiveness of problem management

| $k_{21}$ | The total number of incidents $\rightarrow$ min | 60 | 5 | 999 |
| $k_{22}$ | The ratio of the number of resolved problems to all problems (%) $\rightarrow$ max | < 20% | 80% | 0–100% |
| $k_{23}$ | % incidents, which can not be associated with any problem $\rightarrow$ min | >25% | 10% | 0–100% |

$K_3$ | Quality of customer support

| $k_{31}$ | The degree of customer satisfaction $\rightarrow$ max | <3 | 4 | 0–5 |
| $k_{32}$ | The number of violations SLA $\rightarrow$ min | >30% | 15% | 0–100% |
| $k_{33}$ | The number of services that are not covered SLA $\rightarrow$ min | >35% | 20% | 0–100% |

These criteria and their indicators (metrics) are taken from (Brooks 2006), and they are recommended to evaluate effectiveness of IT-infrastructure in any business organization.

For example, a value equal 10 for an alternative $X_3$ to criteria $k_3$ (see Table 5) means, that the implementation of Service Desk and Incident Management Module will help to increase the ratio of incidents, which are resolved successfully, to its effective value of 90%, etc. The obtained in this way results are given in Table 7.
Table 7  The estimated values for the alternatives with respect to the defined criteria.

<table>
<thead>
<tr>
<th></th>
<th>$K_1$</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$k_{11}$</td>
<td>$k_{12}$</td>
<td>$k_{13}$</td>
<td>$k_{14}$</td>
</tr>
<tr>
<td></td>
<td>(opt= 20min)</td>
<td>(15%)</td>
<td>(85%)</td>
<td>(90%)</td>
</tr>
<tr>
<td>$X_1$</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>$X_2$</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>$X_3$</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>$X_4$</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$K_2$</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$k_{21}$</td>
<td>$k_{22}$</td>
<td>$k_{23}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(opt = 5)</td>
<td>(80%)</td>
<td>(10%)</td>
<td></td>
</tr>
<tr>
<td>$X_1$</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>$X_2$</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td></td>
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<td>$X_3$</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>$X_4$</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$K_3$</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>$k_{31}$</td>
<td>$k_{32}$</td>
<td>$k_{33}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(opt =4)</td>
<td>(15%)</td>
<td>(20%)</td>
<td></td>
</tr>
<tr>
<td>$X_2$</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>$X_3$</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>$X_4$</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>$X_2$</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td></td>
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</tbody>
</table>
To continue the usage of our method presented in Section 3 (Step 3 and Step 4 respectively) using the pair-wise comparison the weight coefficients of relative importance (WCRI designated as \( w(k_{ij}) \)) for the local criteria regarding their global ones were determined:

- WCRI values of the local criteria for the global criterion \( K_1 \):
  \[
  w(k_1) = 0.239458, \quad w(k_E) = 0.239458, \quad w(k_B) = 0.432749, \quad w(k_H) = 0.088335;
  \]
- WCRI values of the local criteria for the global criterion \( K_2 \):
  \[
  w(k_1) = 0.68334, \quad w(k_2) = 0.19981, \quad w(k_3) = 0.11685;
  \]
- WCRI values of the local criteria for the global criterion \( K_3 \):
  \[
  w(k_3) = 0.332516, \quad w(k_2) = 0.527836, \quad w(k_3) = 0.139648;
  \]
- summarized WCRI values for the global criterion \( K_i \): \( K_1 = 0.527836, \quad K_2 = 0.332516, \quad K_3 = 0.139648 \).

And finally, according to Step 5 of this method (see Section 3), and using the multi-criteria ranking formulas (11) - (12), we obtain the following ultimate results of the effectiveness assessment for the considered alternatives (see Table 5), namely

\[
X_1 = 0.537, X_2 = 0.671, X_3 = 0.578, X_4 = 0.727 \quad (23)
\]

To confirm the reliability of the results given with formula (23), the comparative analysis with some “best practices” in ITSM implementation was carried out, using the data of IDC-company (IDC.com 2012). In particular, IDC has reviewed approx. 600 organizations worldwide, which used ITSM for over a year, and in this study especially the prioritization issues of different ITSM-modules implementation were analyzed. In Fig. 10 the result of the performed comparison is shown.
As we can see, to provide Change Management and Configuration Management is necessary to have within an IT-infrastructure database (DB) of IT-configurations, and DB of problem situations as well, these facilities are rather too expensive for the University, and therefore the implementation of these modules is not a priority task. The most effective ITSM-modules configuration for NTU “KhPI” includes an Incident Management module and a Service Desk subsystem.

7.3 Procedure for semantic integration of ontologies

In order to provide ITSMS—EA data integration (see Section 4) the technological scheme shown on Fig. 11 is proposed (Sokol Vlad. 2014).

In process databases used in ITSMS and heterogeneous data resources existing in corporative IT-infrastructure additionally to ontological specifications: Onto_ITSM, Onto_EA and Onto TO defined with formulas (13)—(15) two new technological components are used:

1. the library of special functions for syntax and semantic analysis of initial metadata description schemes of
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information sources to be integrated into the target data structure;
2. the support dictionary for problem domain terms with advanced linguistic-semantic structure.

To elaborate the library (1) the appropriate logical operations have to be designed and implemented, and they are the following:

a) syntax comparison of names for all metadata elements of the ITSMMS and EA data schemes;
b) semantic comparison of names for all metadata elements mentioned above, taking into account the possible linguistic relations between them such as synonyms, hyponyms-hyperons, holonym - meronym that should be determined using support dictionary (see below);
c) data-centered comparison of metadata scheme elements with respect to their data types using the special mapping rules;
d) structural comparison of metadata schemes taking into account possible relationships between several classes that belong to them.

Fig. 11 The technological scheme for ITSMMS-EA data integration

As the support dictionary of domain terms (2) with advanced linguistic-semantic structure the electronic ontological dictionary (WordNet.com

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2016), which is the open Internet resource, currently numbering about 350 000 words of general and technical vocabulary.

For algorithmic implementation of special functions listed below as (a)—(d) the following programming procedure is proposed (Sokol Vlad. 2014), and it is shown in pseudo-code below.

BEGIN main_algorithm_integration:
    \( C, P, R, PZ, a1, a2, a3, a4 \) = Initialization ()
    SplittingNamesIntoSubstrings\((C, P)\)

ElementsLOOP: FOR \( c, p \) in \( C, P \):
    \( SZ(c, p) \) = SyntaxSimilaraty\((c, p)\)
    \( SZZS(c,p) \) = DictionarySemanticSimilaraty\((c,p)\)
    \( ZZTD(c, p) \) = DataTypeSimilaraty \((c, p)\)
    \( StZ(c, p) \) = StructureSimilaraty \((c, p)\)

END ElementsLoop

FindItemToBeJoined\((IE)\)
    \( NeIE \) = FindItemToBeMoved \((IE, C, P)\)
    GenerationIntegratedScheme\((IE, NeIE)\)

END main_algorithm_integration

The meaning of these functions used in this procedure is quite clear from their names (e.g. function SyntaxSimilarity (), etc.), and they are described in details in (Sokol Vlad. 2014). To apply this procedure in praxis the appropriate data model is elaborated (Fig. 12), where all main domain entities (classes) are following

- **Element** is the main class that is responsible for storing the elements of the integrated model data object;
- **Attribute** is a class responsible for maintaining of attributes in integrated model;
- **DataType** class that is responsible for maintaining data type attributes;
- **AttrSplitting** a utility class that is used to store substrings of attribute’s names;
- **ElemSplitting** a utility class that is used to store substrings of data elements;
- **Result** is a class that is used to store the intermediate results matching elements;
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- **AttrResult**: an additional class and is used to store the intermediate results matching attributes;
- **Mapping**: the class that collects data on which will be generated a description of Web-service access to integrated data.

Fig. 12 Data model used the ITSMS-EA integration procedure

Having the procedure shown in pseudo-code below and the data model presented on Fig. 12, and according to the proposed technological scheme (see Fig. 11) the test-case for integration of 2 data models was performed (Sokol Vlad. 2014). These simple input data schemes: “Authorization - User” and “Permission - Customer” are shown in Fig. 13.

In order to measure the accuracy of the proposed integration procedure the following metrics were used

- the Van Rijsbergen’s (or $F_1$) information retrieval metric
where \( p \) and \( r \) are the precise and recall parameters respectively (Olson and Delen 2008),

Fig. 13  Input data schemes for ITSMS-EA integration procedure

- the special quantitative metric to estimate how well the support dictionary contains domain-specific terms to be used for comparison of meta data schemes to be integrated

\[
D_c = \frac{\sum_{i=0}^{n} (f(i) + \alpha \sum_{j=0}^{m} f(h_{ij}))}{n(1+\alpha)}
\]

(25)

where \( n \) is a total number of data elements; \( m \) is a number of attributes in \( i\)-th data element; \( x \) is a number of separated words in \( i\)-th data element; \( f(x) \) is a function to estimate a dictionary fullness that is defined as following; \( f \) and is a search function in dictionary for a given word \( x \) that has 2 possible values \( \{0,1\} \), is a weight coefficient with values between \( [0,1] \), is a vector of attribute names; is a vector of scheme’s element names.

Using metrics (24)—(25) the effectiveness of integration procedure for different configuration of data schemes was estimated, and these results are shown on Fig. 14.
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Fig. 14 Effectiveness estimation for data integration procedure

The charts on Fig. 14 are built in 2-dimensions coordinate system where

- on the horizontal axis the different test configurations are represented that are ordered by their degree of complexity: e.g. case 2 (9,3) x 2 (8,2) represents the 2 data schemes each with 2 classes having corresponding number of attributes (see Fig. 13);
- on the vertical axis values of the appropriate metrics: $F_1$ (in range of [0.1]) and $D_C$ (in %) are given respectively.

These charts quite clearly show that the quality of the integration procedure by the value of the $F_1$ - metric depends on the complexity of the data scheme configurations, and on the completeness of dictionary metric $D_C$. With complexity (or dimension) increasing of data schemes to be integrated both metrics $F_1$ and $D_C$ are beginning to decline, because of some errors accrued during semantic comparison. But at the same time, by increasing value of the metric for completeness dictionary $D_C$, of terms used for semantic comparison, $F_1$ - matric value begins to increase also, because the quality of data integration procedure also can be improved with usage a more completeness support dictionary (see Fig. 11). The more detailed discussion of these issues is presented in PhD-thesis (Sokol Vlad. 2014).
7.4 Testing of Onto-CBR incident management algorithm

Basing on the definitions (16)—(19) given in Section 5, the algorithm to realize the proposed OntoCBR-method for incidents management in ITSNS was elaborated in (Sokol Vlad. 2014). In this paragraph we omit some mathematical details and try to explain its praxis-oriented facets, taking into the example of real data to describe the precedent (or problem situation) arisen by some ITSMS-end user (see Table 3). Additionally to the similarity metric’s definition in formula (19), we proposed to use a simple geometric-centered approach to estimate a proximity for 2 vectors of key words (KW) that describe a current incident and any already given precedent in system database, namely: it can be calculated as a cosine of the angle between those vectors (see Fig. 15).

Fig. 15 Geometric illustration for proximity measure between 2 vectors

It means that for any 2 vectors \( \vec{a} \) and \( \vec{b} \) the proximity can be calculated as following

\[
\cos \varphi = \frac{\vec{a} \times \vec{b}}{|\vec{a}| \times |\vec{b}|} = \frac{x_a \times x_b + y_a \times y_b}{\sqrt{x_a^2 + y_a^2} \times \sqrt{x_b^2 + y_b^2}} \tag{26}
\]

Thus, taking into account the data about some precedent already presented in system knowledge base (see Table 3) and basing on formulas (19) and (26), we illustrate our approach with following concrete data calculations presented below.
**Step 1.** The intermediate results of KW data processing are presented in Table 8.

Table 8  The intermediate results of KW vector processing for the given precedent (fragment).

<table>
<thead>
<tr>
<th>ID</th>
<th>Category of KW</th>
<th>Key word (KW)</th>
<th>Normalized weight coefficient for KW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Department</td>
<td>“IMS”</td>
<td>0.8</td>
</tr>
<tr>
<td>2</td>
<td>Operating system</td>
<td>“MS Windows 7”</td>
<td>0.6</td>
</tr>
<tr>
<td>3</td>
<td>Software tool</td>
<td>“MS Visual Studio 2012”</td>
<td>0.8</td>
</tr>
<tr>
<td>4</td>
<td>Software component</td>
<td>“Plag-in Git Source Control”</td>
<td>0.4</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>....</td>
<td>...</td>
</tr>
</tbody>
</table>

**Step 2.** Assume that the parameter value $\lambda = 0.6$ represents relative weight coefficient for KW in parameter $H$ (text description of header), the parameter value $\beta = 0.4$ is the same for KW in parameter $P$ (text of problem description, see examples for both in Table 3), and the threshold value to get correct precedent is $\varepsilon = 0.4$.

**Step 3.** As the next step we calculate similarity metric for $H$ parameters included in KW vector of i-th precedent and in KW vector of the current incident.

and calculate the same metric for parameter $P$ in both vectors.

**Step 4.** Having two values calculated on Step 2 and Step 3, and taking into account values of relative weight coefficients defined on Step 1 we can get calculate summarized similarity value as following.

**Step 5.** Finally, because the resulting similarity value 0.24 is less than the pre-defined threshold value $\varepsilon = 0.4$, then the current precedent cannot be taken as the possible solution for arisen problem situation.
As already mentioned above, more detailed discussion about results achieved with proposed OntoCBR-approach to intelligent incident management in ITSM-systems can be found in (Sokol Vlad. 2014).

8 CONCLUSIONS AND FUTURE WORK

In this chapter we have presented the intelligent complex approach to efficient development and operating of ITSMS, which supposes to resolve 3 interconnected problems for their effective usage in a target organization (in our case: at the University)

1. choosing the effective configuration of ITSM-modules according to its specific features and needs;
2. elaboration the integration framework for data resources of a given ITSMS and an already existing Enterprise Architecture;
3. providing the advanced incidents management in ITSM systems.

To solve these problems in a comprehensive way the interdisciplinary integrated framework is elaborated, which includes: the expert method for multi-criteria ranking of alternative ITSM-modules configurations, the ontological specifications for ITSMS-EA integration, and an approach to advanced incident management based on the combination of adaptive ontologies and CBR-methodology.

In future we are going to elaborate more detailed models and algorithms for the problems (1)-(3) listed above, to implement and to test the appropriate software solutions for them using such technologies as Java, OWL, BPMN, XML/XLST, and Web-services.

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**KEY TERMS**

Adaptive ontology
Agile-software development
Case-Based Reasoning
Data Integration
Development and Operations (DevOps)
IT-Infrastructure Library
IT-Service Management
Multi-Criteria Ranking
Requirements Traceability Matrix
Scrum-Method
van Rijsbergen’s metric
WordNet dictionary

QUESTIONS FOR FURTHER STUDY
1. Which type of membership function can be used in the method for effectiveness estimation of alternative ITSMS-configurations (see Section 3)?
2. Propose another expert methods to be used for choosing of effective ITSMS-modules configuration (see Section 3).
3. What is the difference between standard ontology and adaptve ontology (see Section 5)? Provide some example of this one for your problem domin.
4. Describe the main collision between ITIL/ITSMS-framework for corporative IT-infrastructure management and any agile-software development methods (e.g. Scrum) used in an appropriate business organization (see Section 6). What is a possible approach to resolve this issue?
5. Which another models and techniques, besides traceability matrix, can be used to specify and to manage relationships between user requirements and software project artifacts?
6. Compare and contrast different metrics that can by applied to measure similarity between 2 points (2 vectors) by case-based reasoning approach to precedents management (see Section 7).

EXERCISES
There are three main kinds of ITSM-systems used in modern business organization (see Section 2.1). What would be a choise for your target business organization with respect to its specific features (motivate this one)?
Elaborate an example of ontological specification (as UML-class diagram) for your business domain (similar to Fig. 2), which should be used for data integration procedure needed for effective ITSMS usage in your enterprise IT-infrastructure.

Analyse carefully the data about typical incident types (Table 5), and the list of possible values of global and local criteria (Table 6) for effective configuring of ITSMS-moduls, and construct the appropriate data tables for your business organization.

In the technological scheme for ITSMS-EA data integration (Fig. 11) as a support dictionary the electronic ontological lexical database WordNet is used (http://wordnet.princeton.edu). Propose the alternative and more powerful open Internet data resource for this purpose.

Which parameter’s value has to be changed in the OntoCBR-algorithm defined as Step 1—Step 5 (see Section 7.4) in order to get the positive decision about the possible usage of the current precedent to solve the arisen problem situation (Table 3)?

FURTHER READING


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INVESTIGATING THE ROLE OF PRODUCT MANAGER IN SOFTWARE PRODUCT ORGANIZATIONS

LEARNING OBJECTIVES
The objective of this chapter is to explore, understand and investigate the role of Product Manager (PM) in software product organizations. Once you have mastered the materials in this chapter, you will be able to:

- Understand the general concept of software product management
- Understand the role and responsibilities of PM in the software product management context
- Explore how PM role fits in with other roles in organizations
- Walkthrough the roles of PM according to the different development phases in software development lifecycle

CHAPTER OUTLINE
This chapter explores the concept of PM role in software product organizations. Product management in general requires a broad perspective and management approach that considers multiple disciplines, such as technology, marketing, strategic planning and engineering, and interactions between these disciplines. Effective management of software products is crucial for the organization success. In this context, software PM plays one of the most important roles for the overall the success. Understanding and grasping the concept of PM role is often overlooked and still is a complex subject. In this chapter, first we have explained the roles and responsibilities of software PMs
and identify the interactions with different roles in software product organizations.

**KEYWORDS**
Product lifecycle, product management, product marketing, role of product manager, software product management, software products

1 **INTRODUCTION**

Today, most of the large and medium-sized technology companies are under pressure to offer their customers faster and better results than ever, due to compelling competition conditions and rapid technological developments. For this reason, it is obvious that these technology firms should take a close look at their approach starting from the beginning of the demand cycle and must keep pace with the customer-oriented product management. Also, when the competitive structure of the market is considered, the importance “Customer” concept emerges and it becomes an inevitable fact that companies must create new product ideas and developments entirely in the direction of “Customer”’s expectations.

Product Management is defined as a strategic and business oriented management approach that is focused on delivering solutions to market needs. From company function perspective, product management can be defined as a company function that is responsible for strategic and tactical success for each product offered. Product management requires a broad perspective and management approach that considers multiple disciplines, such as technology, marketing, strategic planning and engineering, and interactions between these disciplines. These different disciplines define product management in a variety of ways and with their own perspective. A definition made by David Rainey from a marketing discipline perspective defines product management as “Product management is the approach used for managing existing products and services.” (Rainey 2005) A different definition of product management from a holistic perspective is described by Steven Haines as: “Product Management refers to the holistic management of products and portfolios, from the time they are conceived to the time they are discontinued and withdrawn from the market.” (Haines 2013) It is known that the definition of product management role differs from sector to sector and there are even differences in terms of role definition.
and scope among firms in the same sector. However, these differences can also be related to the methods of the product management function. The PM is often considered the CEO of his products and he is responsible for setting up strategies for the product or product group, determining the product roadmap, and defining product characteristics. This list of responsibilities of the product planning activity area can be extended to include responsibilities of “Product Marketing” activity field such as product positioning on the market, implementation of marketing plans, monitoring of competing products and PM role can include many activities from strategic level to tactical level. PMs often analyze market and competition conditions and identify a product vision that can deliver a unique (authentic) value that can respond to customer requests. Nowadays, it is often seen that PMs are working in software companies that deliver products or technology for their customers. In this study, the role of the PM in the software world will be examined and the basic concepts in the concept of product management will be explained. PM roles will be compared in different aspects to other roles in the software world. The rest of the chapter is organized as follows, in Section 2 we have defined the product management. In Section 3, we have explored the concept of product manager, by giving an overview, discuss the ideal skill set, and in Section 4 mention typical roles of PM according to the phases of the product lifecycle.

2 WHAT IS PRODUCT MANAGEMENT?
Product management can be defined as a company function that is responsible for strategic and tactical success for each product offered. Product management emerges as a professional field that includes two professional disciplines named “product planning” and “product marketing”. Product functionality is created for the end user through product planning. The value of the product is transferred to the buyer through product marketing. Product management as a professional field that focuses both on product planning and product marketing and is also based on various management techniques. (Steinhardt 2010) A different definition of product management from a holistic perspective is described by Steven Haines as: “Product Management refers to the holistic management of products and portfolios, from the time they are conceived to the time they are discontinued and withdrawn from the
market. In essence, Product Management is the business management of products. (Haines 2013) In companies, each department has a certain level of expertise and they perform various tasks in order to be successful. Developers develop solutions that solve customer problems. Marketing specialists work to create product value and communicate with customers to maximize awareness and interest in products and services. Sales specialists are responsible for closing the sale of products to customers. The operations teams ensure that the solution is delivered efficiently and at low cost and the company works as cost-effectively as possible. Customer support teams help solve customer problems quickly. Product management seems to have a holistic viewpoint in this picture. While it appears that product management is at the heart of all company departments, it is also in contact with other external stakeholders, such as customers, press, analysts and partnerships. Product management is a group that takes responsibility for all aspects of the product and understands how all parts come together to achieve the product's success. In order for the product to be successful, short-term tactics should be applied and a product strategy should be established to extend this success to a longer period. (Lawley and Schure 2017) Product management not only defines the vision for the product, but also includes understanding the product market, targeting customers and working with the product team to make the product more attractive. Today, companies with a successful product management seem to have a much higher success rate. The business environment includes social, economic, political, regulatory, market and technological forces that bring about various opportunities and challenges that can lead to changes in the organization. Social and economic forces have significant impacts on stakeholders and other elements of the organization. Political and regulatory factors set the various criterias and conditions that must be included in the new product development process in order to guide the need for new products and to ensure that all legal requirements are met. Market forces generally affect the applicability of existing products on the market. Changing market conditions and trends may create new conditions that can not be satisfied by existing products. Such changes will affect the life cycle of existing product offerings and create numerous opportunities for new products. Technological forces offer new ways and tools to meet customer and stakeholder needs and to enable new products to
be produced by customers. All of these forces provide opportunities to meet the needs of the business environment by producing new solutions, thereby speeding up the introduction of new products. (Rainey 2005) Product management includes technical and marketing functions that enable the organization to present products and services to existing customers and new markets. In addition, product management can provide information and data to support new product requests. Nowadays, especially in high technology companies, every company sees and carries out product management activities in many different ways. This leads to a lack of standardization of the product management discipline. In order to ensure the success of companies, it is necessary to have a consistent understanding of product management and to deal with all aspects of product management. Product management is a combination of activities that deeply impact the success of a product. For example, addressing wrong market requirements, non-realistic pricing, or misidentified target market can lead to adverse and critical consequences. Another thing to be aware of in product management is that even if one of the faulty conditions occurs, it can greatly reduce the success of the product. (Steinhardt 2010) Companies with formal and well-defined product management practices are companies that realize that product management is a key strategic function for the organization. These companies try to make sure that the product management processes are properly run and applied. There may not be an excellent product management process behind all product successes. Some products are successful because of external factors, timing or just strong capital. However, it is clear that many product failures are driven by poor product management. (Steinhardt 2010) The key to commercial success of products in the high-tech world is to blend effective product management methodology with disciplined technology development practices. Product management discipline and profession has reached a greater level of maturity and acceptance in the high-tech industry. One of the ways to implement product management effectively is to become a market-oriented organization. In order to gain market-oriented status, a company must implement a proactive product management process and engage and listen to its customers before the product is planned, defined, designed and developed.
3 WHO IS A PRODUCT MANAGER?

3.1 HISTORY OF PRODUCT MANAGEMENT

The concept of product management has been the focus of business managers and decision makers since the 1930s. Execution of the product management profession by individuals from different disciplinary expertises has led to the definition of “coincidental” for the profession. Product management was first implemented in the fast-moving consumer goods sector in 1931 as a management approach. In the fast-moving consumer goods sector, it is seen that the concept of PM and brand manager are used simultaneously because each product is named with a different brand and launched to the market. (Lawley and Schure 2017) In the early 1950s and 1960s, with the influence of rapid economic growth, many companies in the fast-moving consumer sector put their product management philosophy into practice with the introduction of new products to the market. In the 1970s and 1980s, product management focused more on new production technologies and on cost reduction in production. The market conditions of the 1990s have caused competition wars. Companies have been tempted to think about new product development and new market creation, and product management has been considered together with “new product development”.

3.2 PRODUCT MANAGER’S ROLE

Today, the traditional product management approach has almost entirely changed as a customer-focused product management approach. Companies create new products completely in line with the expectations of their customers. Customer expectations and satisfaction are among the most important success criteria for companies. With this new approach, the market life of the products is getting shorter and shorter.

PMs play a unique role in an organization. (Lawley and Schure 2017) They: Investigate and discover market/customer needs and customer preferences,

- Create the vision of the product.
- Transfer this vision to the rest of the organization.
- Define and prioritize the business outcomes needed to achieve the vision.
• Obtain the resources to build and maintain the product.
• Work with the development team to translate market/customer requirements and business outcomes into features.
• Interact with all stakeholders to ensure product success.

Many organizations switching to the product management model are slightly moving away from the traditional project manager concept and allowing the PM and the self-organizing teams to manage the details in an effort. The role of PM adds value to the firm by filling in some areas where it is difficult for many organizations to fill. PMs have field expertise and are directly responsible for the success of the product. However, program management may take place at a certain level in order to be able to cope with conflicts on resources. Product management provides cross-functional leadership - interconnecting the different functions within the company, especially between engineering-focused teams, sales and marketing and support. (Lawley and Schure 2017)

The PM is often considered to be the CEO of his products, but he is also responsible for setting up strategies for the product or product group, determining the product roadmap, and defining product features. This list of responsibilities for product planning activities can be expanded to include responsibilities of “Product Marketing” activity field such as product positioning on the market, implementation of marketing plans, monitoring of competitors’ products. The role of PM can include many activities at strategic and tactical level. PMs often analyze market and competition conditions and identify a product vision that can deliver an original value that can respond to customer requests. Customers have an important list of your product that includes product features and functions, as well as any non-interest items. These additional features of your product are called the augmented product. They should be aware of the product promises and how the augmented product meets those promises. It is the responsibility of the PM to work on any disconnection between customer experience and product promises. (Lawley and Schure 2017) Product managers should plan how to execute that vision through product iterations, design, roadmaps, and features. He should zoom in to the fine detail, where there’s working with the development, and other teams. PM must remove the obstacles in the path of the product realization while keeping the overall plan on track. PM also should work with the marketing and sales teams to plan
and execute the product launch. After the launch, the success of the product should be measured and the necessary actions should be taken. PMs can perform these activities over and over again within the target of product realization.

3.3 PM’s SKILLSET
The scope of tasks of PMs includes a broad range of skills. However, there are several key components and areas that are summarized below, it is observed that PMs who have experience, knowledge and skills have been observed to be more successful. (Lawley and Schure 2017)

▷ **Domain Expertise**: PM is an expert in domain area. He knows customers and business.
▷ **Leadership skills**: PMs demonstrate good leadership skills.
▷ **Operational capability**: PMs may need to deal with operational details to manage a product.
▷ **Communication Skills**: PMs communicate very frequently. They should respond quickly to problematic situations through excellent written and verbal communication skills.
▷ **Impact on Stakeholders**: PMs use communication skills and more to engage and bargain with the many stakeholders. They show excellent team work skills.
▷ **Analysis Skills**: PMs demand, formulate and deduce meaningful results from quantitative and qualitative data.
▷ **Empathy**: PMs show great deal of empathy for their customers and for all of their stakeholders.
▷ **Future thinking**: PMs can see the future for existing products and new product ideas, and they can create almost concrete visions.

The activities and primary responsibilities of the PM are given below.

- Creates the product vision, strategy and roadmap.
- Collects, manages and prioritizes market/customer requirements.
- Acts as a customer advocate, expresses the needs of the user/buyer.
• Works closely with engineering, sales, marketing and support to ensure business objectives and customer satisfaction goals are met.
• Has technical product knowledge or specific domain expertise.
• Establishes the market needs document and specifies which problems will be solved on the market.
• Provides beta and pilot programs for products and samples.
• PM is a market expert. Market expertise involves understanding the reasons customers buy their products. This means a deep understanding of competition and how customers think and buy a product.
• Acts as product leader within the company.
• Develop a positioning strategy for the product.
• Assists to determine product pricing by providing information.
• Works closely with the product marketing department.
• Explores competitors’ products.
• Prepares product demos.
• PM is the central point of contact for the product within the company.
• Makes sure that the sales professionals get the required training for the product.
• Conducts customer research and market analysis, generates new ideas for new products or features, and prioritizes those ideas.
• After the product idea is selected, PM plays an active role in the realization of the planning phase. In order to support the company’s strategic and financial goals, PM performs a comprehensive study around the concepts of market strategy, customer needs.
• Informs the engineering team of market requirements and ensures that the product produced can solve the problems of their customers.
• Works with external customers to verify whether the product is officially ready to be marketed on the market.

4 PM ROLE BY PHASES
The development of a product will start with the concept. Market research will be performed and market opportunities will be identified.
Ideas can come from many different directions. They will be evaluated and prioritized and best ideas will be selected. Value proposition and positioning statements should be developed for selected idea. The activities that are performed by Product Management roles in Concept phase are listed below.

- Segment markets and identify market opportunities.
- Define customer targets and assess customer needs.
- Identify customer problems.
- Detect industry trends. Uncover opportunities/generate ideas.
- Enter ideas into the repository and classify them. (New product, new product feature, product enhancement)
- Evaluate and prioritize the ideas.
- Assessment of strategic alignment and establishment of strategic baseline.
- Select the ideas to move forward with.
- Produce opportunity statement for selected idea/s.
- Develop value proposition for selected idea/s.
- Develop positioning statement.
- Evaluate competitors and compare competitor products.
- Configure product SWOT.
- Present all of the information and recommendations to the committee. (For go/no go decision)

Feasibility phase will ensure that ideas are tested for their viability. The voice of customers’ data will be gathered and analyzed. Buyer personas will be created to understand the potential customer. Also first drafts of the business documents should be written. In essence, it is time to carry out in-depth research and analysis. Let’s list the activities that are performed by Product Management roles in Feasibility phase.

- Develop a plan for collecting voice of the customer (VOC) data.
- Gathering the voice of customers’ data.
- Analyzing voice of the customer (VOC) data.
- Define the market segmentation, identify and verify the target markets.
- Define buyer personas to understand the potential customer.
- Further verify and clarify Value Proposition.
- Perform full competitor analysis (competitive products, potential competitive products, competitors, and competitor capabilities)
- Develop/recommend product pricing strategies and structures.
- Identify/recommend the distribution channels.
- Perform ROI (Return on Investment) analysis.
- Create sales or market share projections.
- Develop first draft of Business Case document.
- Develop first draft of Marketing Requirements Document (MRD) initiated to articulate the characteristics and capabilities of the product.
- Assist for developing first draft of Product Requirements Document (Product Description Document) (PRD) to define features and functionalities.
- Develop first draft of Product Roadmap Document.
- Develop first draft of Market Strategy Document. (Prepare go-to-market strategy and launch plans that outline in detail how the product will be sold.)
- Review the positioning statement and expand upon where necessary.
- Create prototypes.
- Present all of the information and recommendations to the committee. (For go/no go decision)

In “Product Definition” phase, business analysis will be performed with subject matter experts and customers. An important focus during this phase is finalizing business documents (Market Requirements Document, Product Requirements Document, Business Case etc.) that specify the product in detail. Also, product brand and product logo should be defined in definition phase. In the next phases, product will be developed and launched. The activities that are performed by Product Management roles in Product Definition phase are listed below.
- Perform business analysis with subject matter experts and customers.
- Work up for detailed user/customer/buyer personas.
- Identify and quantify resources.
- Finalize business case once all this data is gathered and analyzed.
- Finalize market research and MRD—Market Requirements Document
- Fully define product requirements and finalize PRD - Product Requirements Document
- Finalize product roadmap document.
- Put the technical specification together and finalize SRS - Software Requirements Specification Document
- Finalize market strategy document.
- Conduct Make v. Buy analysis.
- Define product launch readiness and success metrics.
- Test and validate product idea. (the minimum viable product or rapid prototyping)
- Define product brand.
- Define product logo.
- Define the tools that will be used to gather customer feedback during development.
- Define product launch readiness and success metrics.
- Start to think over sales tools and marketing collateral (e.g. demos, presentations, brochures, data sheets).
- Communicate product roadmap and requirements documents and/or the SRS with team members.
- Communicate product/marketing plans and strategy with management and get approval.

The Product Launch and Development phases are often simultaneous phases. The workload on the Product Launch Phase increases as the workload on the Product Development Phase declines. PM should collaborate with team on product definition and execute product roadmaps. PM also provides leadership to the development team. The activities that are performed by Product Management roles in Product Development phase are listed below.

- Collaborate with team on product definition and product roadmaps.
- Execution of the product roadmap.
- Write and finalize Beta Test Plan.
• Communicate requirements (e.g. prepare use cases, scenarios) in a way that is unambiguous and easily understandable to both development/engineering.
• Provide leadership to the development team.
• Monitor and track the progress of the product development against all plans including the business case, the PRD and so on.
• Hold regular cross-functional and executive board status meetings/updates.
• Monitor market at all times for any changes that may impact the product.
• If any relevant changes are perceived then act upon them immediately. (e.g. Change prioritization of the features to implement. Update product roadmap.)
• Monitor the change control process.
• Update existing customer related documentation or the producing of new documentation.
• Make sure that the product is tested and complies with all requirements.
• During development, gather needed customer feedback from prototypes or mock-ups and communicates the results of this feedback to the appropriate team members.
• Arrange the training dates for beta test programs, customer training and/or internal training programs or test market programs for the product.
• Execute and complete any required beta test programs, customer training and/or internal training programs or test market programs for the product.
• Assess the results of usability testing, beta testing and test marketing and takes appropriate corrective action.
• Write and finalize launch plan.
• Identify product enhancements and line extensions.
• Update documents and finalize feature list.
• Generate user manuals, training materials and other documentation.
• Monitor product launch readiness and success metrics.
• Evaluation of the progress and its environment to see if any elements put the launch at risk.
The activities that are performed by Product Management roles in Product Launch phase are listed below.

- Review all the documentation and update business documents if necessary.
- Write Marketing Plan
- Produce sales enablement materials that help reps close more deals. (Blog Posts, Whitepapers, Case Studies, Product Sheets, Competitor Comparisons, Presentations, Social Messages)
- Set market window or announcement date.
- Make announcement of the product to the market.
- Executing product launch strategies.
- Produce sales, customer services, channel partner and for key customers training materials.
- Arrange the training dates for sales, customer services, channel partner and for key customers about products and solutions
- Create launch content including everything from demo decks to product website, landing pages.
- Create Marketing Communication materials to support the product/product line (specific media, the public relations activities, the direct mail programs, the collateral materials, the publicity events)
- Implement the marketing plan.
- Align the marketing effort to ensure that all parties can deliver in time for the launch.
- Complete all training activities for sales, customer services, channel partner and for key customers
- Create industry trade show strategy.
- Provide product communication to a wide variety of audiences i.e. customers, senior management, internal groups, analysts, social media, the press and internal departments and at industry events.
- Take part fully in a range of industry events including: conventions, panels, forums.
- Submit and present white papers to establish the businesses leadership in the marketplace.
- Ship the product.
- Start to monitor marketing and sales.
After launch of the product, post-launch product management activities should be performed. This is called “Growth—Maturity—Decline” and usually the longest phase of the product lifecycle. The main act of the Post-Launch phase is to run the day to day operational and monitoring processes. Let’s see the activities that are performed by Product Management roles in Post-Launch phase.

- Conduct post-launch audits by looking at all the project plans and documentation.
- Analyze whether or not the plan was achieved and what disconnects there were.
- Look at whether each goal describe across each document was met.
- Check out whether or not the assumptions that were made in the business case proved to be correct.
- Review the financial performance of the product against the forecasts made.
- Share the results throughout all levels of the project team.
- Support the sales process (e.g. provide product sales expertise, input for RFPs).
- Hold cross-functional team meetings or workshops to discuss the lessons that need to be learned.
- Run the business with all the day to day operational and monitoring processes that involves.
- Promote the product externally with press, customers, and partners.
- Support the sales team, attending industry conference, forums, events and writing articles or white papers.
- Monitor marketing mix strategies, change the marketing mix as required and optimize.
- Review and analyze P&L, balance sheet and cash flows.
- Review, sustain and extend the product as necessary and monitor the market and competitors.
- Gather customer feedback, visit customers, act as a point of contact for issues arising. Track customer satisfaction.
- Addressing complaints and resolving problems.
- Identification of new target markets.
• Continually monitor the marketplace, customers and competitors and industry development.
• Maintain product and market knowledge. Perform analyses of market trends.
• Monitor metrics and KPIs and evaluate the results.
• Conduct win-loss studies.
• Analyze product profit and loss.
• Refine value based pricing.
• Evaluate channel performance.

All products have a lifetime and need to start being phased out from the market eventually. PMs should determine when the product needs to be withdrawn from the market by monitoring financials. The normal indicators for the product being in decline are, declining sales, loss of market share, revenue from the product is minimal, and the product no longer aligns with the businesses goals. Let’s see the activities that are performed by Product Management roles in End of Life phase.

• Issuing of legal notices to customers, partners.
• Give the final support date for the product and any information that may be required.
• Discontinue marketing efforts.
• Narrow down the distribution channels.
• Alter pricing to a higher level to discourage new purchases.
• Phase out of the product.

REFERENCES
KEY TERMS
PM
Product Life Cycle
Product Management
Software Product Management
Software business
Product Management Frameworks
Product Marketing
Software Products

QUESTIONS FOR FURTHER STUDY
1. Describe the top 5 responsibilities of a product manager.
2. Compare and contrast role of Product owner, role of Project manager, and role of Product marketing manager.
3. What are the main phases in new product development? Briefly explain each of the phase.
4. In your opinion, what are the top 3 skills to be a successful product manager?

EXERCISES
Suppose you are hired as a PM in a software product organization. The product you took over is in the launch phase. Previous PM will be with you for your orientation. What kind of information would you ask to the previous PM? Describe also your short-term strategy when you take over the position.

You are a PM in a software product organization. The development team is asking for an advice from you on selecting the proper software development methodology.

Would you use Waterfall methodology to develop the system, or would you prefer one agile software development methodologies? Compare and contrast the advantages and disadvantages of each approach from the product management point of view.

You are a CEO of a software product organization. You need to hire a PM for one of your e-commerce software products. Write a complete job ad to hire someone for that position. Make sure to include what
skills and experience you require for the position. Describe the general requirements for that position as well.

FURTHER READING
Geracie G. Take Charge Product Management, Chicago: Actuation Consulting (Actuation Publications), 2013
INNOVATION AND TECHNOLOGY TRANSFER IN EMEA REGION – A SUCCESS STORY FROM 1001 NIGHTS

ABSTRACT
The general purpose of the Technopolis is to ensure the technology transfer, to contribute the regional development and especially to transfer the scientific studies and researches into the application sector primarily to industry. Technology Development Zones support start-up and research companies as well as supporting the companies within the zone about the research and innovation concept. Within the scope of this purpose, it supports regional development strategically. In this paper, the activities and success criteria of the Technopolis which has achieved big success in a short time will be analyzed.

KEYWORDS
Technology Transfer, Teknokent, Technology Scorecard

1 TECHNOLOGY TRANSFER
Technology transfer is the process of transferring scientific findings from one organization to another for the purpose of further development and commercialization. This process includes (1) the identification of new technologies, (2) the protection of new technologies through patents and copyrights, and (3) forming development and commercialization strategies (Dubickis/Gaile-Sarkane 2015, Allen et al. 2014, Codner et al. 2012). Academic and research institutions engage in technology transfer for several reasons, such as (1) local economic development, (2) recognition for the institution, (3) compliance with federal
regulations or (4) licensing revenue to support research and education (Basin/Hoang 2013, Rodríguez 2009). ADAPTTTO-Technology Transfer Office was founded in the University of Sakarya (SAU) within Sakarya Teknokent in 2013. It is aimed to convert the knowledge to the new and competitive products or processes, to create added value and to increase the licensed patents for commercialization by collecting the fund of entrepreneurship technology transfer and science of the University. In accordance with this purpose, it is aimed to increase the skills of technologic, entrepreneurship, research and development of private and public institutions by taking advantage of national and international research support programs for researchers and industrial companies. The aims of ADAPTTTO is (1) to inform the stakeholders about the foundation philosophy of ADAPTTTO, the function of interface systems and activities and to develop strong communication mechanism with these stakeholders as well as the expertise of the economic staff of SAU, the collaboration potential, and infrastructure facilities, (2) to make use of national and international grant support fund for academicians at maximum level by applying one-to-one service manner, (3) to be an interface between the university and business world by giving direct and pro-active services, (4) to provide consultancy to academians about the extension of the Intellectual and Industrial Property Rights concept, (5) to evaluate, manage and commercialize of project outputs generated by the SAU or other colleagues within the scope of IPR, (6) to leverage the incorporation and entrepreneurship culture dealing with the business development. ADAPTTTO-Technology Transfer Office consists of five modules as 1) Awareness, Publicity, Trainee and Informing Module 2) Project Support Module 3) University-Industry Collaboration Module 4) Intellectual and Industrial Property Rights 5) Incorporation and Entrepreneurship Module.

2 SAKARYA TEKNOKENT

2.1 Organizational Profile

In 2009 Company’s official establishment being done with Sakarya University Technology Development Area’s announcement by Council of Ministers in 2008. First R&D firms passed to Sakarya Teknokent’s constitution in November 2009. In 2010 90% fullness rate was ensured. 15 firms were built in Sakarya Teknokent’s constitution in December
2010. New Sakarya Teknokent's building's substructure lay in 2010 and 8 new firms joined Teknokent family and our Teknokent grew with exactly 23 firms. And with this successful rapid growth in a short time, our Teknokent has being awarded in 2012. Sakarya Teknokent was awarded in performance size up prepared by Science and Technology Ministry. In Turkey general, Teknokent became forth and its own category Teknokent became premier. We believe this success will continue without a break. In 2013 with Sakarya Teknokent's new complex's finish, to our country and our city Technology Transfer Office was built and gained with the name ADAPTTO. With the end of the year, 34 more firms built in Teknokent's constitution and they are continuing their active studies. ADAPTTO is going forward with confident steps to become the ruling ADAPTTO in our area. In the last three years, the number of companies in Sakarya Teknokent has tripled. The revenue per company has tripled as well. The Sakarya Teknokent revenue increased seven times within the last three years. In this context, ADAPTTO the day it was built it is continuing its studies in such fields: introduction and awareness, project supports, university-industry collaboration, ideological and industrial ownership rights and lastly entrepreneurship and incorporation (see Fig. 1).

Fig. 1  Development of Sakarya Teknokent
2.2 Vision & Mission

Vision and Mission of Sakarya Teknokent are defined below:

**VISION**

- To play an active role in technology-based R&D and innovation activities in the regional industry
- To support the R&D activities and entrepreneurship
- To create qualified awareness in the society about the R&D and innovation
- To create university-industry collaboration corporeally
- To contribute the activities about the technology-based foreign companies can invest in the R&D and innovation about the technology-based investment in maximum.

**MISSION**

- To convert the information, culture, and technology based on the human, industrial, financial and economic to the advantages in the innovator dimension of our country for 21st century and to provide a raise our life quality to the future with the strategical targets
- To present the best and the most appropriate world class services professionally to the companies and firms playing roles in the R&D and innovation areas
- To encourage the collaborations before the competition and to create a synergistic atmosphere between firms having similar working subjects in universities
- To encourage the existing small-scale companies and to encourage new entrepreneurs to set up new companies having potential on technology-based production capacity

2.3 The Upward Movement of Sakarya Teknokent

Companies allowed to have their operations in the region have tax exemption under the Technology Development Zones Law. R&D personnel employed in the region, researcher personnel and software personnel fees are exempted from income tax until 31.12.2023. Income generated from R&D and software development activities executed exclusively in the region are exempted from corporate tax (natural entities are exempted from income tax) until 31.12.2023. During the
period in which earnings of entrepreneurs having their operations in the region are exempted from income or corporate tax, all deliveries and services produced in these regions and related to system management, data management, business practices, sectoral, internet, mobile and military command control application software are exempted from value added tax. R&D personnel employed in the zone, researcher personnel and software personnel is exempted from the sharing of 50% of SSI for each personnel for 5 years. SAU Instructors can set-up their spin-off in Sakarya Teknokent, can become a shareholder of an existing company and also can be a shareholder for an existing company (see Fig. 2). Considering the geographical location of Technopolis, it is seen that the region is a developed zone in terms of the industry. Despite this, IT companies have a substantial sharing. The basic reason is that the spin-off organizations have played an active role in the field of IT sector. Furthermore, these organization can make the researchers happen with less resource and more rapidly compared to other sectors. In addition to this, being a significant share of machinery and equipment industry, it emphasizes the research activities together with the Technopolis and universities (see Fig. 3). When the number of employees has been analyzed as well as the sectoral distribution, it is easily seen that the most staffs have worked in R&D field. Besides, being 162 personnel in Technopolis have emphasized the given importance to the research (see Fig. 4). Technopolis has worked on only placing the companies within its structure but also it provides services about the conveying and announcement the opportunities to the companies and also coordinating the synergy environment between the companies from different technoparks. The active projects of Sakarya Teknokent have been analyzed, there are available 85 ongoing projects and 117 completed projects (see Fig. 5).
Fig. 2  Increase of companies in Teknokent

![Number of Start-ups / Spin-offs](chart1.png)

Fig. 3  Sectoral distribution of companies in Teknokent

![Sectoral distribution](chart2.png)
When we analyze the infrastructure and environment situation of Sakarya Teknokent the understanding the opportunities supplied for operations, the following situation arises (see Fig. 6).
### 2.4 Public-University-Industry Collaboration (KÜSİ)

- Public-University-Industry Collaboration cooperated more functional
- Performing the activities of Technopark more integrated to the other institutions/organizations

**Purpose:** To create professional collaboration by establishing a bridge between the academic World and the business World in order to provide scientific, technological and economic contribution by combining the academic knowledge of the university and the financial power of the company.

**Target Group:** Industrial enterprises, universities, research institutes, R&D Centers.

**Services:** Informing and training about TÜBİTAK and TEYDEB, project writing, project process management, academic consultancy service.

**Activity Methods:** Corporate travels, academicians travels, academicians matching, training and seminars about TÜBİTAK incentive programs
3 HOW TEKNOKENT CONTRIBUTES TO THE SUCCESS OF SME AND START-UP COMPANIES

The following support can be used for the spin-off/start-up enterprises:

- No income tax for employee working toward R&D,
- No corporation income tax for the start-ups,
- No VAT, exclusively for IT and software developer start-ups,
- A state-of-the-art technology transfer office helping start-ups in order to commercialize their project outputs,
- Full service of proposal preparation for external funding (TUBİTAK, KOSGEB, Horizon2020 etc.),
- Grant for your R&D projects ranging from 40% to 100% of your total project budget (i.e., if your project budget is 500,000 Euros, you will get a grand amounting from 200,000 Euros to the whole budget with no refund),
- Full access in all Turkish R&D and Innovation ecosystem.
- Sakarya Teknokent is one of the pioneering technoparks located in Sakarya/TURKEY.
- Low rental costs starting from just 15 Euros per m² in the modern buildings,
- Tenants can rent offices starting from 15 m² to 150 m², or larger by merging two neighbor offices,
- Being with the Sakarya University (www.sakarya.edu.tr/en) in the same campus.
- Sakarya University was ranked to be 24th of the most entrepreneur and innovator University in Turkey in 2016.
- Sakarya University has more than 70,000 students and 1000 professors of various disciplines in both social and physical sciences with the modern buildings laboratories and infrastructure offering an excellent opportunity for possible collaborations in between university and industry.
- Sakarya is in the first 10 largest economies in Turkey with 6 Organized Industry Zones.
- Sakarya city and therefore Sakarya Teknokent sits at the center of most known metropolitans such as Istanbul (1 hour), Ankara (2.5 hours), Izmir (1 hour by plane).
There are many ways to support the SME and other firms, provided contributions have been defined in entrepreneurship support package. Mostly significant supports can be listed as financial supports, tax advantages and networking between the companies (see Fig. 7).

4 Technology Transfer Scorecard Template

The balanced scorecard represents a performance measurement instrument, where objectives, measurands, and strategic actions are categorized according to a specific structure, which is designated as a dimension. The balanced scorecard was designed by Kaplan and Norton. They focus on finance, customers, learning & growth, as well as on an internal dimension. For every dimension, the main targets, objectives, measurands, and measures have to be developed, showing how the dimensions can influence each other (Kaplan, Norton 1996). Later on, the Balanced Scorecard approach was further developed and researchers added different dimensions to those that Kaplan & Norton proposed. The main results of these approaches were that the Balanced Scorecard approach is a flexible one, in which further dimensions such as customers, target markets, and suppliers up to a number of eight can be added and evaluated easily using this approach (Erkollar, Oberer 2015; Erkollar, Oberer 2012, Kaplan, Norton 2004). Nowadays, the balanced scorecard approach is frequently used for most activities in organizations, such as strategic management, marketing, process management, or employee management. The balanced scorecard approach does not depend on the type of organization, which means it can be used for enterprises, governments, non-profit organizations, as well as for single departments in these organizations or in several cases for employees (Erkollar, Oberer 2015, Goncharuk 2011; Grigori et al. 2010, Leung et al. 2006). Companies seek alternatives in order to develop their product, services, and internal processes, and overcome barriers caused by globalization and technological hype. The following technology transfer scorecard is a template scorecard for technology transfer centers, partly filled with sample metrics.
Fig. 7  Support package for entrepreneurs

Table 1  Technology Transfer Scorecard (template)

<table>
<thead>
<tr>
<th>#</th>
<th>Metric</th>
<th>Goal</th>
<th>Results</th>
<th>On target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Startup Companies launched</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td># of licensing deals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>revenue received</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td># industry collaborations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>economic development index</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Metric</td>
<td>Goal</td>
<td>Results</td>
<td>On target</td>
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<tr>
<td>----</td>
<td>--------------------------------------------</td>
<td>------</td>
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<td>-----------</td>
</tr>
<tr>
<td>6</td>
<td>cost per patent filling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>annual patent maintenance fee</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>goodwill to the institution (1=low, 10=high)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td><strong>Customer Dimension</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td># of customers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td># of patent applications filed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td># of patents issued</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td># of invention disclosures filed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td># of invention disclosures marketed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td># of innovation training sessions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td># of innovation training certificates issued</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>innovation survey results (annual)</td>
<td></td>
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<tr>
<td></td>
<td><strong>Internal Dimension</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>disclosure to screening cycle time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>patents issued to # of deals ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td># of success stories published</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Metric</td>
<td>Goal</td>
<td>Results</td>
<td>On target</td>
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<td>----</td>
<td>---------------------------------------------</td>
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</tr>
<tr>
<td>4</td>
<td># of award applications submitted</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td># of website enhancement</td>
<td></td>
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<tr>
<td>6</td>
<td># of blog postings</td>
<td></td>
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<tr>
<td>7</td>
<td>...</td>
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</table>

**Development Dimension**

<table>
<thead>
<tr>
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<th>Metric</th>
<th>Goal</th>
<th>Results</th>
<th>On target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td># of staff training hours</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td># of workshops and conferences attended</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td># of papers submitted for publication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td># of disclosures to # of licensing professionals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>staff turnover rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>AVG staff years of service @ transfer center</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>...</td>
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Financial dimension, including measures that indicate whether an organization is achieving key bottom-line results. Customer dimension, including measures that monitor the value proposition that an organization delivers to its target customers. Internal Dimension, including measures that track how effectively an organization is performing. Development dimension, Learning and Growth Perspective, including measures
on internal organizational investments to improve their performance in the other three areas. The Balanced Scorecard concept is not only applicable for commercial enterprises, it might be used by governments, non-profit organizations and academic institutions, such as technology transfer centers. The balanced scorecard helps to focus and align an entire organization on what must be accomplished to ensure the overall success of the organization, to translate overarching goals and objectives into tangible results that an organization aims to achieve over a set time period, to serve as an effective communication vehicle to communicate performance results within the organization, to provide the management with a comprehensive view of overall operations. Once key performance indicators were identified, it is critical to implement a process and define roles and responsibilities for capturing pre-defined metrics, review process results and develop an action plan for defining key measures. To implement a scorecard methodology in a technology transfer center, these centers have to (1) outline their plans for the center, (2) Conduct research on industry standard technology transfer key performance objectives, (3) identify key performance indicators, (4) define annual goals for each performance indicator and (5) implement a communication process for the technology transfer scorecard.

5 SUMMARY
Technocities are one of the important factors for the economic and industrial development. Especially, supporting the companies for R&D activities, creating a bridge between the companies and supporting on the connection between the companies for university-industry collaboration. From point of this view, a technopolis is also one of the significant factors that contribute the country economic development. Sakarya Teknokent has been an outstanding company in terms of the realized activities since the day of establishment. Technology Transfer Scorecard Template can be applied in many different Technopolis structures thanks to its easy applicable flexible structure. The evaluation criteria can be designed according to the demanded conditions. Adapting of criteria according to the Technopolis structure provides the extended usage area in a variety of Technocities. The important concept of this study is the evaluation of the Technopolis that is considered separately
from the company evaluation within the Technopolis and mainly the total output can be measured.

REFERENCES


