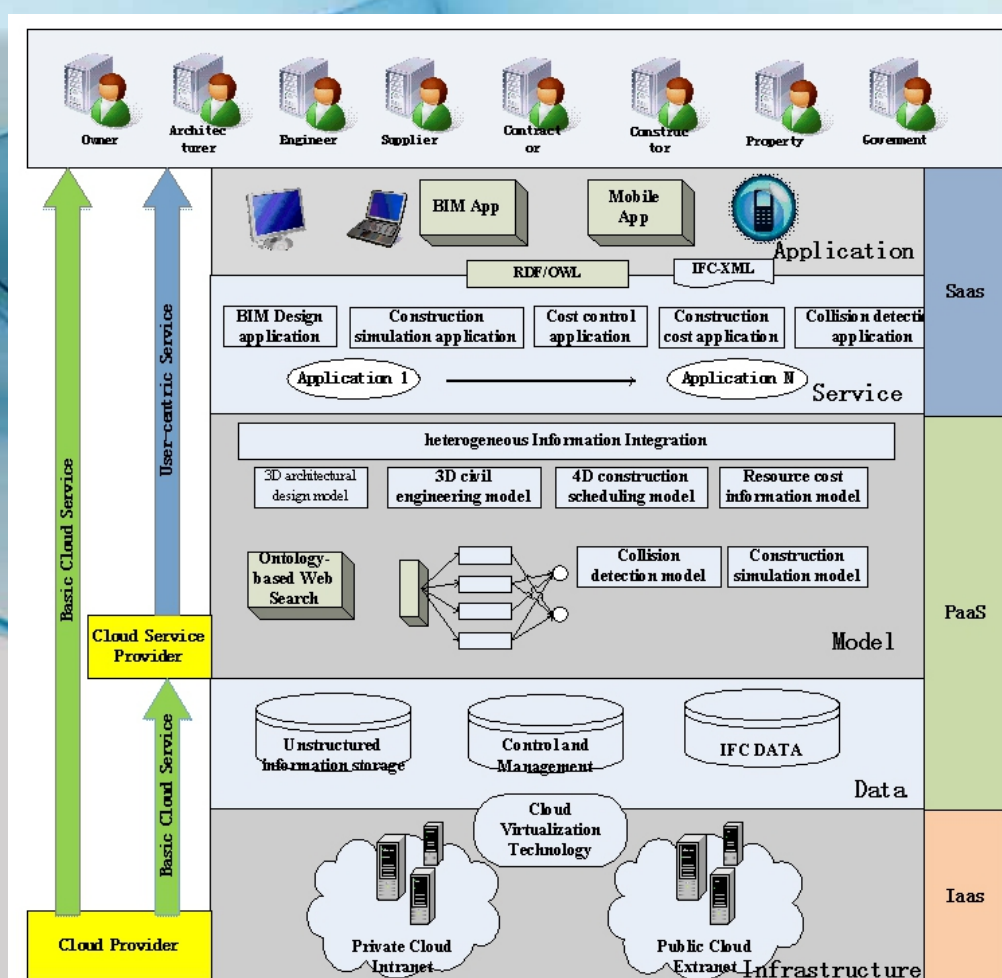




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Table of Contents

Volume 7 Number 2

April 2014

Cloud and Open BIM-Based Building Information Interoperability Research

D. Juan, Q. Zheng.....47

Perception of Farmers on Extension Services in North Western Part of Nigeria: The Case of Farming Households in Kano State

H. Ibrahim, J. Zhou, M. Li, Q. C. Chen.....57

The Development of a Data-Centred Conceptual Reference Model for Strategic GRC-Management

V. Nissen, W. Marekfa.....63

On Real-Time Accounting of Inventory Costs in the Newsvendor Model and Its Effect on the Service Level

T. Avinadav.....77

On Service Productivity: The Emerging Platforms Perspective

W.-T. Hung, S.-T. Yuan.....92

Portraying the Social Dimensions of Consulting with Structuration Theory

C. Maurer, V. Nissen.....110

Progress in the Development of Environmental Risk Assessment as a Tool for the Decision-Making Process

K. K. Wu, L. P. Zhang.....131

Determinant Factors in the Internationalization of Knowledge-Intensive Services in a Peripheral Area

M. Muñoz-Guarasa, E. M. Pajares.....144

An Integrative Framework for Customizations on Satisfaction: The Case of an Online Jewelry Business in China

V. Cho, C. Lau.....165

Food Risk Management and Sustainable Development

F. Yamina, B. Noureddine, D. Mebarek.....182

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Cloud and Open BIM-Based Building Information Interoperability Research*

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Abstract

The emergence of Open BIM effectively improves the interoperability of building information. Besides, cloud technology supports virtualization and QoA (Quality of Assurance) in the case of the distributed system and multi-user collaboration. Based on the cloud and the Open BIM, this paper puts forward the cloud services models and the cloud-based Open BIM building information interaction framework, and further illustrates the architecture of cloud deployment pattern and the information interaction process. Finally, the paper takes underground rail transit project as example and explains how to deploy and implement the tunnel construction management platform.

Keywords

Open BIM, Cloud, Interoperability, Tunnel Construction

1. Introduction

In the development process of the Architecture Engineering Construction (AEC) industry, as the lack of unified standard and integration mechanism to build information interoperability, the information exchange and sharing between different building application systems in the different phases of the building life are difficult. Besides, thus phenomenon formed the information islands and faults, hindered the application of information technology in the field of construction, so as to influence the production efficiency of construction industry [1]. With the appearance of BIM technology around building life cycle, it is realized that the building information integration and sharing between different parties and different stages. BIM provides the technical support to solve the low

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efficiency problem caused by the poor information transmission [2]. With the mature of cloud technology, it becomes more convenient to access remote data servers and applications based on web services. Thus the combination of the open data-exchange mechanism and distributed network architecture provides effective technology platform in AEC industry [3].

2. Literature Review

2.1. BIM and Open BIM

BIM is the full name of Building Information Modeling. On the basis of 3D digital technology, through a common standard, BIM integrates various construction project related information data models. BIM are digital construction representations with rich data, object oriented intelligent and parametric characteristics. BIM provide the coordinated information to all the parties involved in the project throughout the life cycle. BIM fulfill the following construction work such as the analysis, visualization, construction drawing, quantity statistics, etc, so as to help users increase efficiency, cut costs, and reduce environmental impact [4]. In the specific practice of BIM, the potential value of the information exchange around the building life cycle has not been fully realized. The storage and read of BIM information, the transformation and transition of BIM model are restricted by many factors, the most significant one of which is the realization of information interoperability, namely the exchange and sharing of project information between participants and different application systems. Because of the characteristics of the building information, such as huge quantity, complex types, wide resources and scattered storage, the efficiency and effectiveness of information communication and exchange between each sub-system and the various project participants is critical vital to the successful implementation of the project. Traditional way of information interaction mainly through API (Application Programming Interface), or by developing a special intermediate file formats, such as DXF, SAT, 3Ds, etc., to realize transformation and integration of sub-models. These two approaches in use cover a common problem, compatibility [5]. Mostly it can only solve the model transformation between individual software, and once function or version changes, conversion middleware also need to adjust and adapt.

In order to improve the interoperability, the Open BIM initiative, organized by building SMART and the major software vendors such as GRAPHISOFT, Tekla, is put forward [6]. Open BIM is the data management and model method not dependent on specific software or format. The current mainstream Open BIM use public product data IFC (Industry Foundation Classes) to realize information interaction. IFC is the BIM data standard released by the International collaborative work union (International Alliance for Interoperability, IAI). Based on the experience of the industry STEP standard, IFC is the construction data representation and interchange standard that computer can process [7]. The goal of IFC is to provide a neutral mechanism that independent on the specific system and suitable for describing product data throughout the building life cycle and can effectively support the data exchange between various application system and related construction data management.

The data model structure of IFC standard (IFC Schema) can be divided into four layers, including the domain layer, interactive layer, core layer and resource layer, each layer contains certain information description module, and each layer can only reference the same level and the information resource of lower level, and can't quote the upper level's resources. The resource layer of IFC standard is mainly used to describe the basic information of the model, and thus information is general information independent of the specific construction. The core layer defines the basic framework of the IFC data model, and organizes the information of the resource layer into structured data, such as the Product entity, Process entity and Control entity. The sharing layer defines multiple shared concepts and the objects, resolve the information interaction between different areas. The domain layer defines the specific concepts and information entities of a construction project. This article is based on the IFC's data model structure to complete information interoperability framework.

IFC provides the geometric information and non-geometric properties of the building components, as well as the connection between the components, covering all the data structure at various stages of building life cycle. Although IFC covers all the objects of building life cycle, in the process of practical application, IFC cannot completely solve the problem of building information interoperation. Because the IFC data model just gives the general data structure of building and does not give detailed description for specific building project. Therefore, based on use case to define information interaction requirements become another important aspect of the IFC development, namely the Information Delivery Manual (IDM) [8]. IDM module provides a set of basic building process, and through the analysis to use case, information handbook defines the key points in the process of in-

formation exchange, which contributes to building design and construction of information interaction. IDM will become the important foundation of sub-model extraction and conversion.

2.2. Cloud Service in AEC

As two pillars of BIM, IFC and IDM can only solve basic data storage and transformation, and the transfer of the models in the construction project between different stages also need the support of network environment in order to realize the multi-user access and collaborative interaction. The web-based open information model structure can effectively improve the efficiency and convenience of construction information interaction, and can realize the effective management and cross-platform flexibility. Cloud [9] contributes to exchanging information more effectively and efficiently throughout the building life cycle. The possible solution is the binding of heterogeneous applications through a central repository platform, such as in “Cloud” computing, which has created a way for different applications to openly interoperate and exchange information. Cloud computing is both the applications delivered as service over the internet and the hardware and system software in datacenters that provide those services.

Based on the literature, the research related to Open BIM most refers to construction scheduling [10], traditional building design [11] and solar PV simulation [12], where there has a gap to link Open BIM with cloud technology. Besides, the research to cloud in AEC field is also stay in an early stage, such as the construction data storage [13], cloud security [14] and key technologies [15]. Therefore, it is necessary to consolidate cloud computing with Open BIM and research the cloud deployment and architecture.

There are two categories of cloud-based construction information service provider. One is cloud providers who mainly offer the infrastructure and basic service of cloud. The other is cloud service providers who directly serve various classes of users in construction professional field to meet their particular requirements of the development, integration and release of specific service.

According to the characteristics of the construction industry, there are three types of cloud services deployment model:

1) Software as a Service (SaaS): Cloud service providers enable mainstream software packages available on the cloud platform, so users can choose to rent the software service and use the relevant software service conveniently and quickly, simply by a web-enabled device, such as ordinary computer and Tablet PC. Take Autodesk360 as a typical example. Autodesk360 is able to help users to optimized design, visualize, simulate and share data and processes at any time. For instance, users can view and edit engineering design data, or share and view various types of project files via the platform. Users can enjoy the software service without purchasing a great number of expensive hardware and software.

2) Platform as a Service (PaaS): There must be various types of applications different from cloud providers in different kinds of professional software used inside construction companies. The legacy software can also interact with other software through the cloud platform. Users can rent highly integrated application environment offered by cloud providers or cloud service providers in order to create, test and deploy their own application software as well as realize the interaction between the existing software and other software through the interface. Those kinds of service target application-centric users who can greatly reduce or even dispense with their purchase and maintenance costs of middleware products by the platform service.

3) Infrastructure as a Service (IaaS): Cloud providers with a certain power can provide their service to construction domain cloud service providers or construction companies with a certain scale. These users will put the operating system, middleware, and applications into the cloud of the virtual machine and the dynamic elastic cloud infrastructure and platform.

3. Cloud and Open BIM-Based Building Information Interoperability Framework

Cloud and Open BIM-based building information interoperability framework includes Infrastructure layer, data layer, model layer, interactive layer and application layer (Please see [Figure 1](#)). The framework has the similar layer division compared with the IFC standard, which indicates that the Open BIM is highly relying on the IFC standard.

1) Infrastructure Layer

This layer mainly contains all kinds of physical resources and virtual resources: private cloud, public cloud, hybrid cloud and community cloud. By using the virtual calculating technology, virtual storage technology, hardware devices virtual technology and condition monitoring, this layer realize the virtual dynamic matching

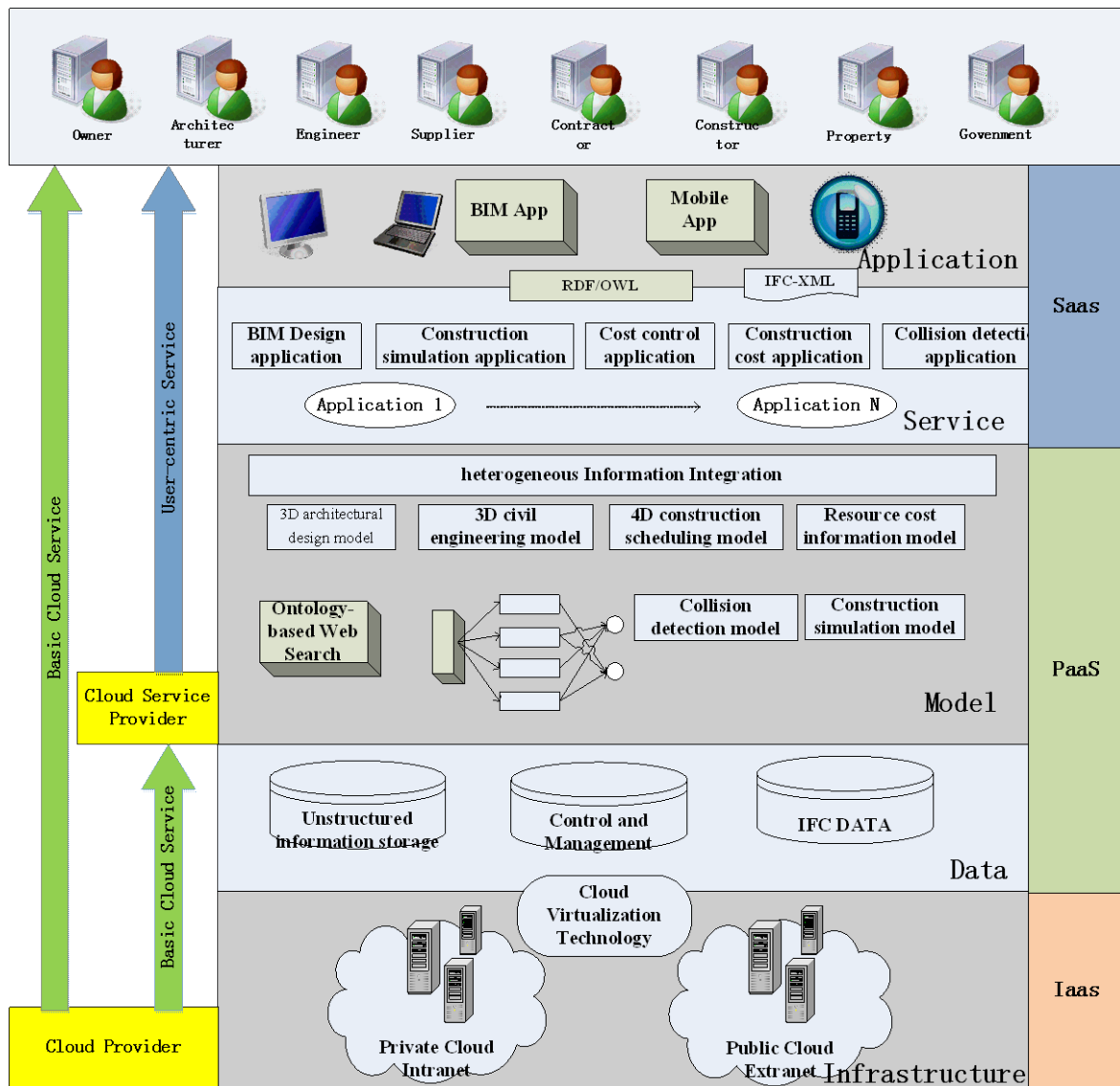


Figure 1. Cloud and Open BIM-based building information interoperability framework.

and provision. Infrastructure layer is mainly composed of cloud providers to provide high reliability, strong customizable, scale extensible service, namely the IaaS services.

2) Data Layer

This layer contains the project information in the whole life cycle of buildings. The information can be divided into three categories, namely the building information model based on the IFC, unstructured data and information (such as RFID data from sensor reading, manual input data, external data from GIS, or media data from audio and video) and process management control information. These data information is stored in a distributed network environment. Through virtualization technology, the huge amounts of data stored on the cloud platform, and will be invoked and processed according to user's demand.

3) Model Layer

This layer mainly includes the combination of the data model used by the specific business process. The building information and information service group are encapsulated based on Web service standards, through the use of semantic based retrieval functions and form business process modeling through the workflow engine. As all kinds of data in the data layer can be expressed by ontology, based on the semantic relations, retrieve result can be formed, such as the data processing model, 3D architectural design model, 3D civil engineering

model, 4D construction schedule model and resource cost information model, collision detection model, etc. Using the Open BIM standard, Firstly, based on the specific business requirement, select or determine the business of IDM, then apply sub-model extraction technology from BIM database to extract the BIM model, then export to IFC files and provide the usage to related application system. Application system use the imported IFC files to realize the engineering information sharing, and then complete the relevant business processes, add new project information, then export the new information and original information to the IFC files. Finally, integrate the new IFC export file into BIM database.

Based on the data layer and model layer, the users deploy and configure their software running environment according the demand. The cloud service providers develop different application services, BIM program interface, BIM service or other auxiliary functions in the development and running environment, namely the PaaS services.

4) Service Layer

This layer mainly includes a variety of heterogeneous applications and software, such as BIM design, construction simulation, cost control, collision detection, etc. the interaction between Software and user client information, can be based on RDF/OWL language to describe. Using XML for data transformation, the user sends a service request and then waits for receiving the server information feedback, without having to download the complete IFC data files, greatly improving the response speed of information interaction. XML Schema due to its complexity, the non-professional users have to write many invalid file, and Web services can effectively solve these problems. Cloud contributes to exchanging information more effectively and efficiently throughout the building life cycle. This cloud BIM middleware will be used to create and modify new data by using SOA and plugins/open APIs.

5) Application Layer

This layer includes the functional project participants and the execution of projects. Based on cloud platform, the stakeholders in each stage of the building life cycle will use different terminal equipment, such as workstations, laptops, tablet, phone or sensor, etc., these devices will visit different web-based applications at the center of the cloud. These applications based on BIM development contain building design, construction operations management and other professional building application. Besides, it also contains the ontology-based web information retrieval App and the mobile devices App.

The user can rent cloud services from cloud service provider according to their own requirements, and pay according to the service types and time, namely SaaS.

4. Cloud Deployment and Information Interoperability Process

4.1. Hybrid Cloud-Based Deployment

This paper will apply a hybrid cloud approach to deploy the architecture (see [Figure 2](#)). The idea show as following: Public and private clouds are isolated through the firewall. Public cloud stores base model libraries related to construction projects and various parties' public data which will form a domain ontology library through transformation. In addition to interactive data in the public cloud, various applications offered by cloud service providers are also contained. Construction project single participants (via a private cloud, internal interaction) or multi participants (via public cloud, multi-interactive) can retrieve and process these applications and data. Participants will automatically realize the extraction and combination of the process-based service through semantic analysis, based on their business needs, which can not only improve the efficiency of data retrieval and architectural model usage, but also ensure real-time transparency of public data and safety and security of private processes. AS this solution combine the private cloud of the intranet and the public cloud of extranet to fix the issue about construction information exchange, it can be regarded as an application of hybrid cloud.

4.2. Cloud and Open BIM-Based Building Information Interoperability Process

The information interaction process involves multiple stages, such as project planning, design, construction, operation, etc., and each stage builds the BIM sub-models in the different process of the project. Then different participants realize the data extraction, extension and integration according to the specific business requirements. Thus, the BIM sub-models continuously develop and evolve, so as to serve different application subsystems. Based on the specific business, the modeling process of information interaction can be shown on [Figure 3](#).

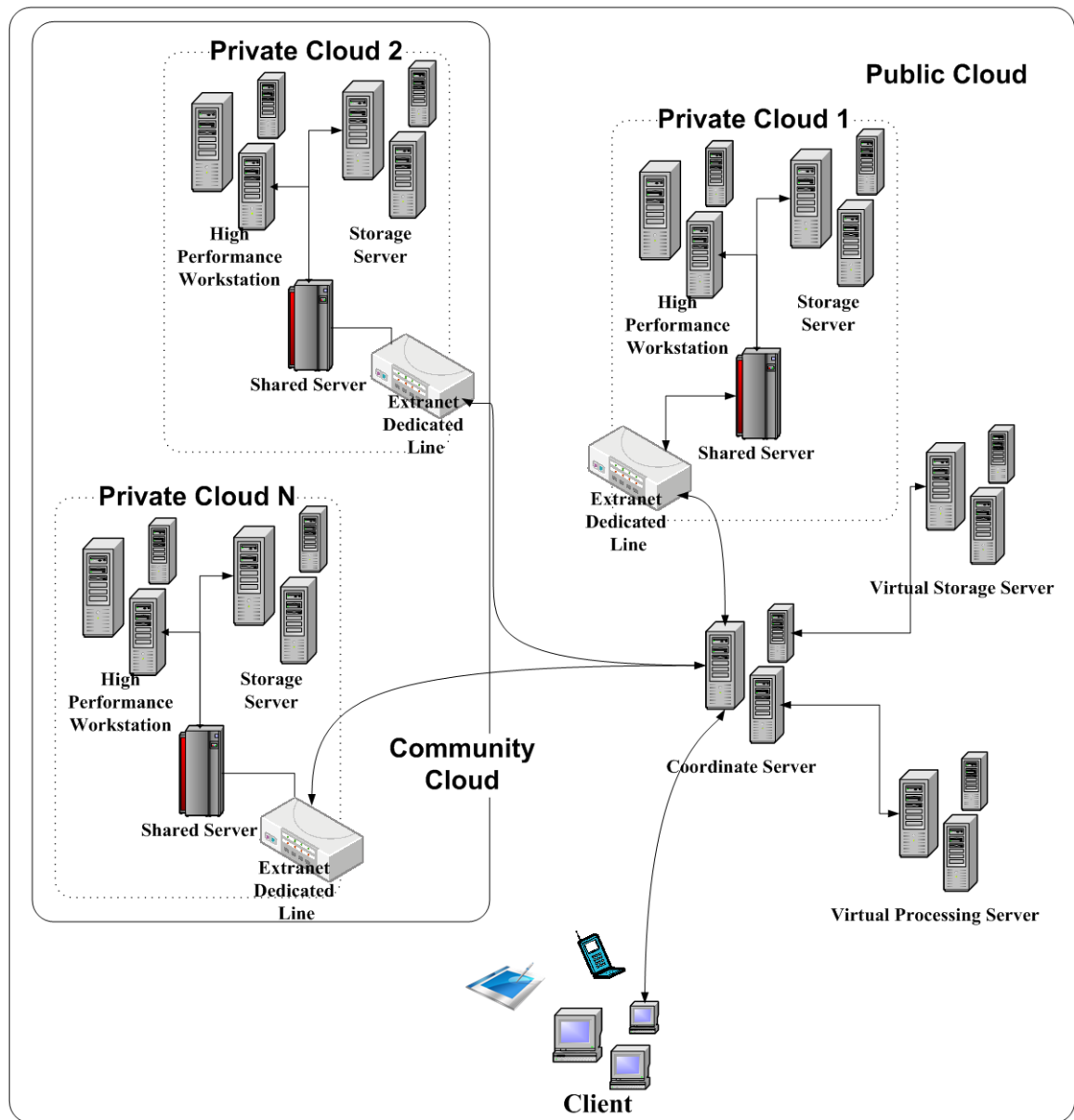


Figure 2. Hybrid cloud-based deployment architecture.

First of all, the project participants based on the specific needs of the business use computer or other mobile devices connect to the Internet and access to the related applications in the cloud platform. According to the specific application, determine whether to call the internal data on the private cloud. If need, then authorize access to the related internal database. If need not, specify the business requirement on the cloudy platform. In the following step, determine whether the specified business has the IDM process specification, and establish the IDM standard according to the business requirements. Then, according to the IDM specification, extracted the BIM model from BIM database. If there is not established business model, it is need to import the IFC files to process modeling according to the IDM process specification, then integrate the sub-models into BIM database.

5. Case Analysis

Recently, with the improvement of Shanghai railway transit construction networks, the difficulty of construction projects is also increasing. In the situation that underground projects are buried deeper and geological conditions

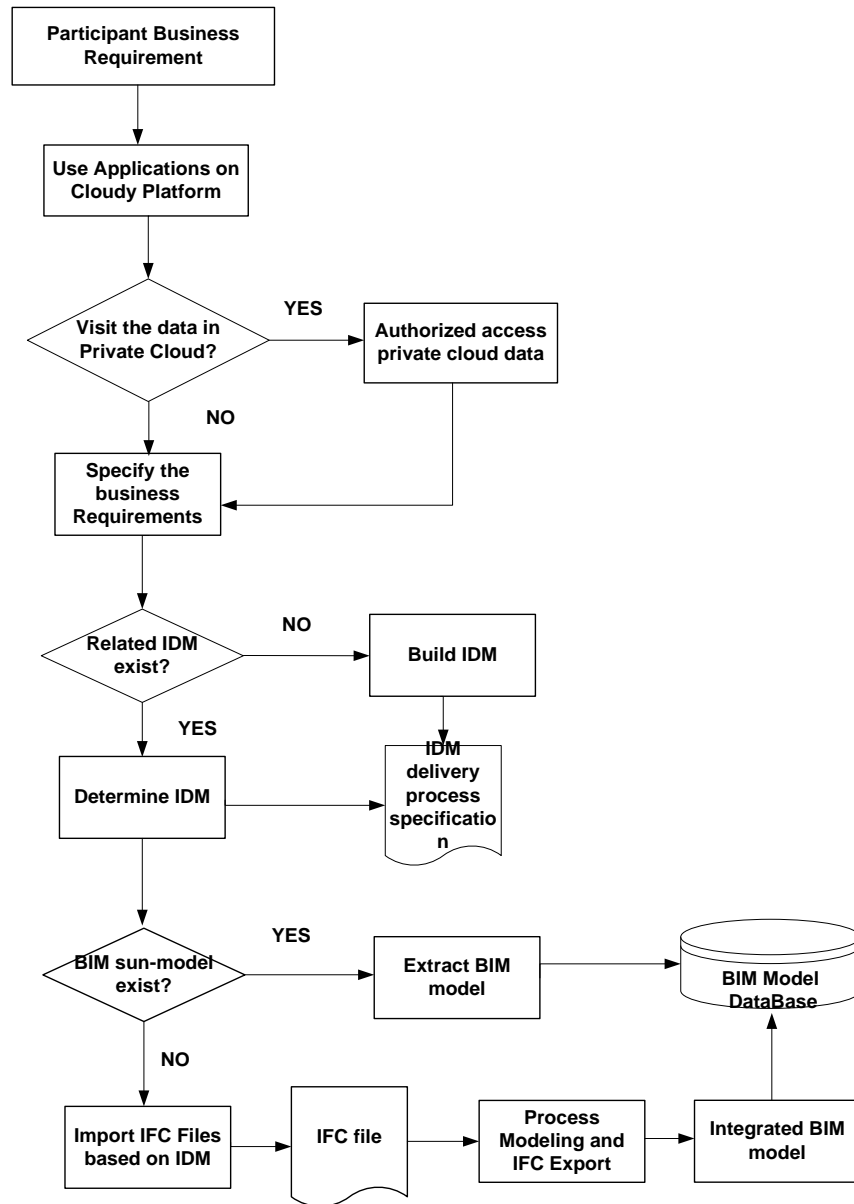


Figure 3. Cloud and open-based building information interoperability process.

are more complicated, how to effectively control the tunnel leaks, ensure project quality and effectively prevent construction risk to stop security incidents have become an important subject for the current project control. In the past research, the BIM-based information management system in the underground tunnel construction has been conducted [16], however, cloud-based Open-BIM building information interaction model will become a new and efficient technology. Take Shanghai Metro Line 12 Project 11 as the application object, the following requirements could be realized using the new technology: the real-time management to realize the quality, safety and supplies of the project; enhance the quality, safety and traceability of materials management; real-time control of the project quantity machine plan and the actual consumption analysis; linkage calibration analysis emphasizing the multi-subsystem; detect and alert project risk timely; the goal to remotely and intelligently show project running integrated data. The above research can realize and implement tunnel construction management work platform.

According to the interaction framework proposed in Section 3, Cloud-based Open-BIM Tunnel Construction Information System is shown in Figure 4. The infrastructure layer of the system can take advantage of external

system, such as personnel positioning system, segment quality system and shield advance system, and collect the information about personnel positioning, segment quality and shield advance into virtual cloud space during the real-time dynamic construction process. The data layer applies heterogeneous data integration mechanism and integrate the information about personnel positioning, segment quality and shield advance into the BIM model and central database through data interface adapter. Such data can be read, used, modified and stored in the data layer based on a certain way. The model layer can read, retrieve, integrate and show IFC model data through the BIM data integration platform. It is able to organize the data from the layer organically to form a model equipped with characteristics and present data under different perspectives against various conditions of construction sites. The service layer can help to integrate and manage each model of the whole system. In addition, guaranteeing the operation of each function module successful is another contribution. The service layer is the link between the user application interaction layer and the model layer. It is also a layer to show the specific function and application of real-time intelligent monitoring platform, including real-time dynamic display to

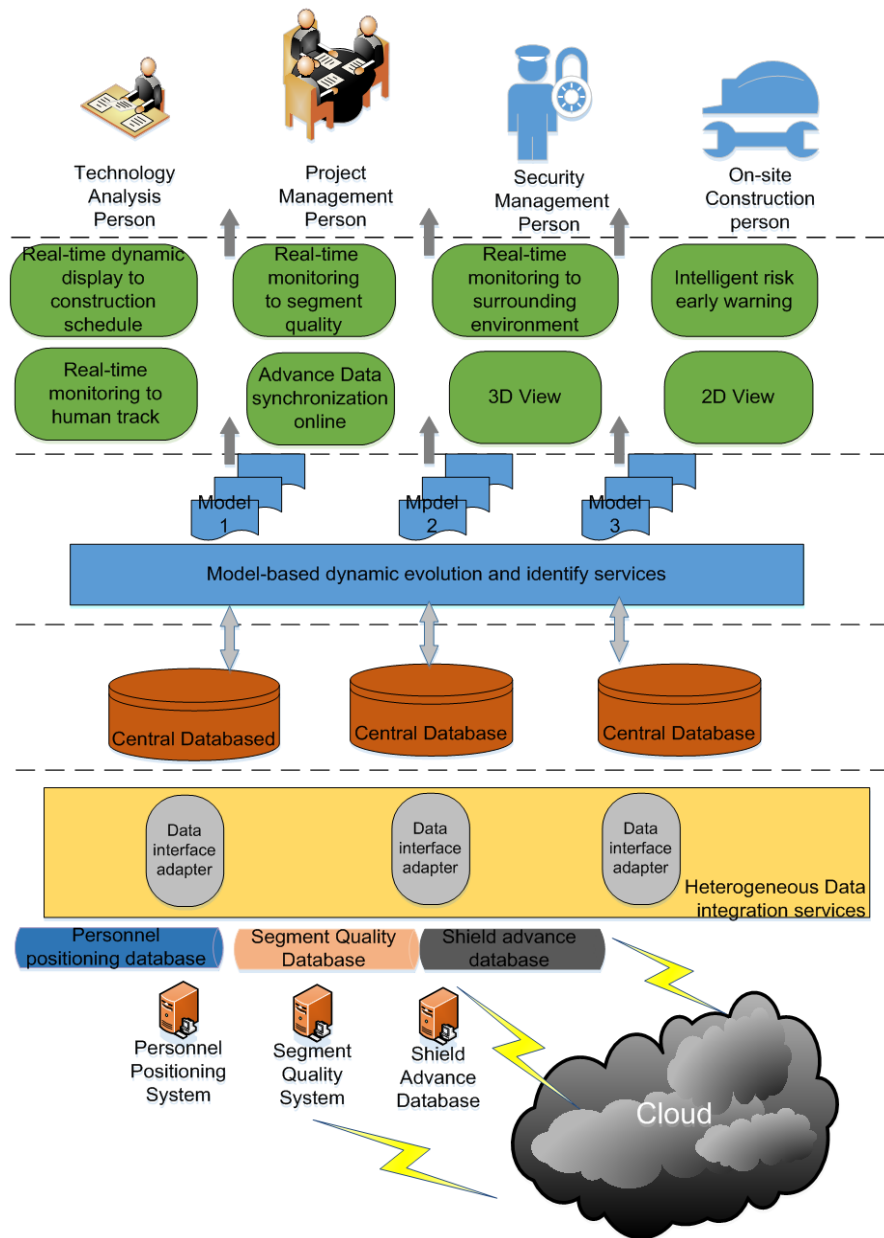


Figure 4. Cloud-based Open-BIM tunnel construction information system.

construction schedule, monitoring to surrounding environment, monitoring to human track, monitoring to segment quality. Due to the corresponding BIM model, the service layer can gain the required model data, share data and apply various application systems based on BIM technology by the distributed operating mode that network technology supports each participant. The application layer mainly realizes the human-computer interaction interface.

The system is deployed around the construction process. Different types of users can conduct remote real-time construction risk monitoring through the corporate virtual private cloud. Tunnel Construction Collaborative Platform Interface is shown in **Figure 5**. Human track system, segment management system and shield advance system (deployed in the private cloud) can automatically transfer the data collected from the underground and aboveground to the core database of the site (deployed in the public cloud) by data collection device. Digital shield tunneling construction systems engineering platform can monitor construction schedule, construction

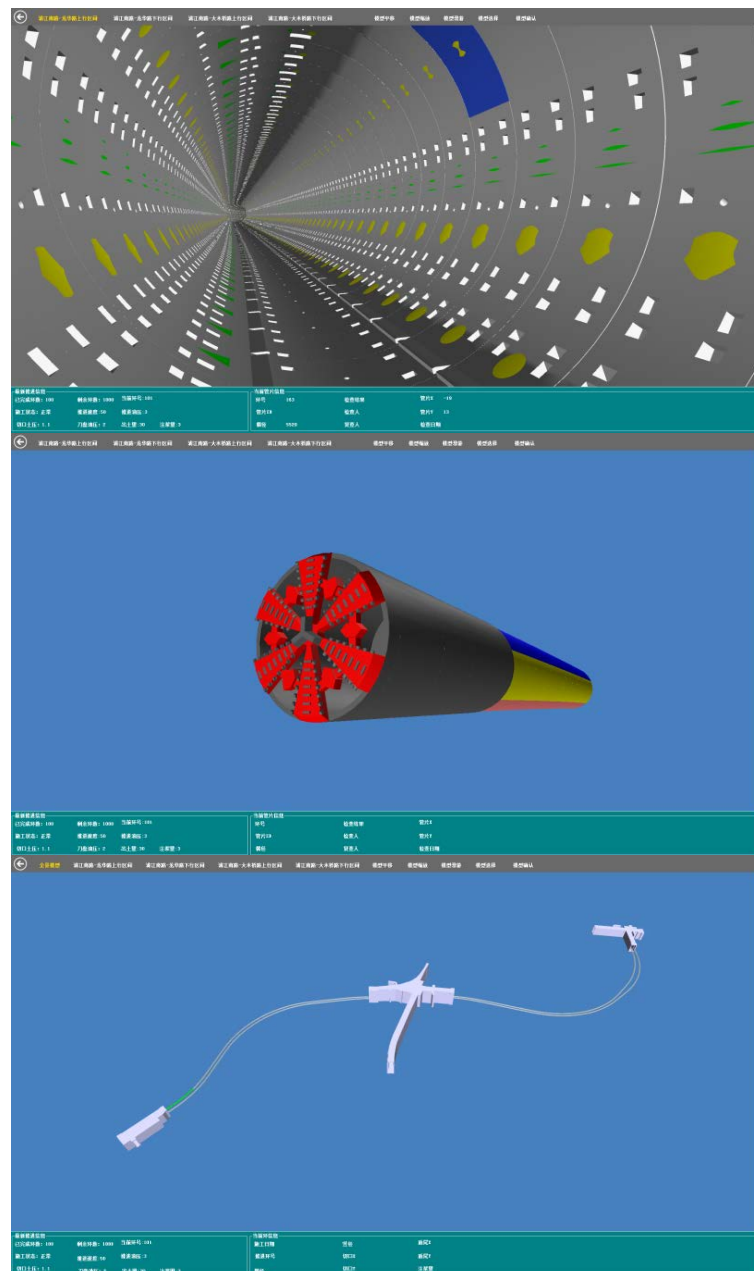


Figure 5. Tunnel construction collaborative platform interface.

quality and personnel security dynamically as well as identify, estimate, warn and control risks through BIM model. When the risk is greater than the warning line, the system will alert to the user by BIM model. Users can develop a detailed understanding of the process of risk formation, a further analysis of risks and a solution through the online early warning data of the model.

6. Conclusion

Cloud technology supports virtualization and QoS (quality of service), owns high reliability and scalability, and facilitates the multi-user collaborative interaction in distributed systems environment. Open BIM, as the standard of building information sharing and exchanging, contributes the interoperability among the heterogeneous data and applications in the whole life cycle of building. Based on the cloud and the Open BIM, the research analyzes the could service mode of building service, puts forward the building information interoperability framework, explains the detailed cloud deployment and illustrates the building information interaction process. Finally, the case of the tunnel construction collaborative platform provides the trend and guidance to the research and practice of information interaction in the AEC industry.

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Perception of Farmers on Extension Services in North Western Part of Nigeria: The Case of Farming Households in Kano State

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Abstract

This study was conducted to determine the perception of farmers on extension services of ADP in Kano state of Nigeria. Multistage sampling technique was used, in which three local governments were randomly selected. Secondly, three wards (divisions under local government) from the selected local governments (Danbatta, Gaya and Madobi) were randomly selected. Thirdly, three villages (one from each ward) were selected. The total number of sample respondent was 120, *i.e.* 40 farming households from each village. The data collected were analyzed with SPSS using descriptive statistics, and Likert scale. The results revealed that, farmers of 35 years of age and below have the highest percentage and 105 out of 120 farmers interviewed were found to be literate. The farmers ranked radio as first extension methods, followed by farm and home visit. Finally, to satisfy their need, farmers should be involved in planning and implementation of extension service.

Keywords

Extension Service, Farmers, Extension Methods, Nigeria

1. Introduction

Agriculture is the key to Nigerian economy accounting for about 40% of GDP and employing about 70% of the active population of over 140 million people [1]. More than half of the populations live in the rural area. It is without contest the leading agricultural power and the largest market in West Africa [2].

82 million hectares out of Nigeria's total land of 91 million hectares were found to be arable. However, only 42% of the cultivable area was farmed and the majority of farmers have an average farm size of 1.2 ha [3]. Agricul-

ture remains a key components of Nigeria's economy, but, the sector significantly underperformed its potentials [4].

Agricultural extension as a system aims to exchange information and transfer skills between farmers, extension workers and researchers to help identify farming problems. This is achievable through an informal, adult training, communicating with individual members of farmers community advice, an assistance with respect to knowledge and methods of technical agriculture, with due consideration of the economic and social circumstances of the individual and other people collectively [5]. A nut shell extension is an educational process that uses varieties of methods designed to help farmers improve living standard. Similarly, extension methods could be used for understanding the best ways to handle farmers so as to meet their need.

Extension organization seeks for employees who are competent in at least five different areas. Namely, technical competency or level of knowledge and understanding related to the crops and livestock that farmer produces; economic competence, or the ability to weigh alternative productive input and output to determine whether the adoption of new idea is advantageous; science competency or an understanding of the philosophy of science and ability to conduct simple field experiment to test an innovation and assess result [6]. Traditionally, extension was concentrating on training farmers, increasing production and transferring technology. Today's understanding of extension goes beyond technology transfer to facilitation, beyond training to learning and helping farmers to help themselves, in other words assisting farmers on how to think not on what to think.

Nigeria has the largest national agricultural research and extension NRES), made up of 17 commodity-based research institute, specialized national agricultural extension institute, 18 faculties of agriculture in regular federal universities, 3 specialized university of agriculture, and one international agricultural research Centre (IITA) [7].

In Nigeria, agricultural development program (ADP) plays the role of extension delivery services in the agricultural sector. It refers to the research institute for improved technology, in order to effectively deliver services to the farmers. The problems that emanate from agriculture at grass root levels are transfer to the scientist by the extension personnel and the solution in form of improved technology are disseminated to the farmers for implementation [8]. The major challenges of Nigeria's agricultural extension services have been identified to include: lack of legislated agricultural extension policy, inadequate and untimely funding, poor leadership and coordination, low private participation, very weak research-extension-farmer inputs linkage system driven by ineffective top-down, supply-driven extension approaches [9].

Ayesha and Mohammad [10], reported that in many developing countries, wide adoption of research results by majority of farmers remain quite limited. This situation calls for smooth flow of information from farmers to researchers and from researcher to farmers this passage is provided by agricultural extension services. But, unfortunately extension services have failed in performing its role efficiently and effectively. This research work is to find out the effectiveness of different extension methods used by extension personnel in disseminating improved agricultural technologies to farmers.

1.1. Problem Statement

According to Anandajayasekeram [11], in a rapidly changing world, food and agricultural innovation system are facing new and increasing complex challenges: Fighting poverty, ensuring food security and improving living standard of farmers. New mechanism to foster development and diffusion of innovation are needed to strengthen the ways in which information, knowledge and technology are developed and disseminated to ensure that the global changes benefit small holder farmer. Similarly, agricultural extension service operates from the backdrop belief that increased agricultural productivity depends primarily upon the acceptance of improved cultural and technological changes at the rural farm level and that peasant farmers can achieve higher farm yields only if they adopt recommended scientific farming techniques in place of their traditional practices. These could only be channeled through effective extension services which are assessed from the farmers' view point. However, extension services in Nigeria perform poorly.

Significance

This research will bring out farmers view point on the effectiveness of extension service provided by Kano State government of Nigeria through Agricultural Development Program (ADP). Hence, preconditions for extension agents to be effective include ability to communicate, attitude to extension work, frequency of contact with far-

mers and field responsibility, which are all examined on farmers' view point. More so, extension effectiveness will be determined by the level of awareness of extension service created among farmers. This research will assist in providing more information about farmers and government effort toward agricultural development, hence aid in policy formulation on agricultural extension service.

1.2. Objective

Specifically, the objective of these researches is to determine the general information of farmers and their perception on the effectiveness of extension services render by the extension personnel.

1.3. Justification

Information of farmers and their perception on extension services provides and promotes participatory approach. Thus, improving demand-driven extension services, which facilitate ways for assisting farmers through increasing food production, poverty reduction and uplifting farmer's standard of living.

1.4. Methodology

This research was conducted in Kano State of Nigeria in which multistage sampling technique was used. Dambatta, Gaya and Madobi local governments were purposively selected out of the 44 local governments in the state. At second stage, three ward one each from one of the selected local governments were randomly selected (*i.e.* Ajumawa, Wudilawa and Madobi ward). Similarly, one village from each ward was randomly selected. Thereafter, 40 households were randomly selected from each village. The total number of sample respondents was 120, *i.e.* 40 households from each village. The data collected was analyzed with the help of SPSS using descriptive statistics, Likert scale and standard deviation [10].

2. Result and Discussions

2.1. Age

The result in **Table 1**, shows that 61 out of the 120 respondent's age are 45 years and below and 35 are between 46 - 55 years old. Implying, that majority of the farmers are physically active in agricultural production, as well as adoption of improved agricultural technologies.

2.2. Education

It was found that 105 of the respondent are literate while 15 are illiterate. Thus, 57% of the respondents have attended senior secondary school and 7% had post-secondary education. Similarly, 19% attended primary education while 17% attended junior secondary education. These indicate that the level of education of the farmers will facilitate effective communication and farmers need to be literate to responds rationally to new technologies.

2.3. Farming Experience

The result indicates that, 63% of the farmers have more than decade of farming experience as shown in **Table 2**.

Table 1. Age-wise distribution of respondents.

Location	Illiterate		Literate		Total	Level of Education				Total
	No	%	No	%		Primary	Junior	Senior	Post-sec	
Ajumawa	3	8	37	93	40	6(16)	2(5)	26(70)	3(8)	37
Wudilawa	2	5	38	95	40	7(18)	7(18)	21(55)	3(8)	38
Madobi	10	25	30	75	40	7(23)	9(30)	13(43)	1(3)	30
Total	15	13	105	88	120	20(19)	18(17)	60(57)	7(7)	105

Source: Field survey.

Thus, indicating that agriculture is an important source for their livelihood. Hence, committed to it.

2.4. Extension Service

Ineffective or inappropriate extension service contributes to decline in agricultural production. Thus, extension is a link between farmers, researchers and extension institution or organization. **Table 3** shows that, 68% of the farmers had contact with extension service while 32% had not. However, 31 farmers out of 40 farmers interviewed in Madobi had no contact with extension. But 38 and 35 respondents in Wudilawa and Ajumawa had contact with extension service.

2.5. Ranking of Extension Methods Used by Extension Personnel

The ranks assigned to each methods used by extension service in innovation dissemination among farmers was determined using a 5 point Likert scale [2]. **Table 4** and **Table 5** show that, the farmers assigned a rate of v.poor, poor, average, good, and v.good to rate each method. Accordingly, 1, 2, 3, 4 and 5 scores were also assigned to each. The weighted scores of each method determine its rank as obtained by multiplying the frequency of responses from each column. The result indicates that radio was ranked 1 with mean ($m = 23.80$) and standard deviation ($SD = 27.25$), farm and home visit ranked 2 with $m = 18.40$ and $SD = 18.24$, print materials ranked 3 with $m = 19.40$ and $SD = 15.14$. However, office calls ranked 8 with $m = 12.80$ and $SD = 12.64$.

Table 2. Distribution of respondents according to farming experience.

Location	Farming Experience (years)						Total
	5 - 10		11 - 15		16 and above		
	No.	%	No.	%	No.	%	
Ajumawa	17	43	12	30	11	28	40
Wudilawa	11	28	15	38	14	35	40
Madobi	10	25	11	28	19	48	40
Total	38	32	38	32	44	37	120

Respondents Age (in years)									
Table Location	Up to 35		36 - 45		46 - 55		56 and above		Total
	No.	%	No.	%	No.	%	No.	%	
Ajumawa	15	38	9	23	11	28	5	13	40
Wudilawa	8	20	7	18	15	38	10	25	40
Madobi	13	33	10	25	9	23	8	20	40
Total	36	90	26	65	35	88	23	58	120

Source: Field survey.

Table 3. Respondents contact with extension personnel.

Location	Contact with Extension Personnel				Total
	Yes		No		
	No.	%	No.	%	
Ajumawa	35	88	5	13	40
Wudilawa	38	95	2	5	40
Madobi	9	23	31	78	40
Total	82	68	38	32	120

Source: Field survey.

Table 4. Perceived effectiveness of methods used by extension personnel.

Location	Activities	Perceived Effectiveness of Extension Methods						Total
		No Activity	V.Poor(1)	Poor(2)	Average(3)	Good(4)	V.Good(5)	
Aajumawa		12(30)	1(2.5)	2(5)	14(35)	8(20)	3(7.5)	40
Wudilawa	Farm/Home Visit	4(10)	0(0)	0(0)	15(37.5)	17(42.5)	4(10)	40
Madobi		12(30)	2(5)	1(2.5)	12(30)	10(25)	3(7.5)	40
Ajumawa		14(35)	4(10)	5(12.5)	13(32.5)	4(10)	0(0)	40
Wudilawa	Office Calls	9(22.5)	0(0)	1(2.5)	18(45)	12(30)	0(0)	40
Madobi		33(82.5)	3(7.5)	2(5)	2(5)	0(0)	0(0)	40
Ajumawa		10(25)	1(2.5)	6(15)	13(32.5)	8(20)	2(5)	40
Wudilawa	Demonstration Plots	3(7.5)	0(0)	1(2.5)	15(37.5)	18(45)	3(7.5)	40
Madobi		22(55)	3(7.5)	10(25)	2(5)	3(7.5)	0(0)	40
Ajumawa		4(10)	3(7.5)	8(20)	14(35)	7(17.5)	4(10)	40
Wudilawa	Farmer Training	9(22.5)	0(0)	1(2.5)	13(32.5)	16(40)	1(2.5)	40
Madobi		7(17.5)	9(22.5)	8(20)	14(35)	2(5)	0(0)	40
Ajumawa		2(5)	4(10)	5(12.5)	23(57.5)	5(12.5)	1(2.5)	40
Wudilawa	Local Fair	13(32.5)	0(0)	0(0)	16(40)	11(27.5)	0(0)	40
Madobi		13(32.5)	3(7.5)	8(20)	14(35)	1(2.5)	1(2.5)	40
Ajumawa		8(20)	3(7.5)	8(20)	11(27.5)	7(17.5)	3(7.5)	40
Wudilawa	Workshop	4(10)	0(0)	0(0)	21(52.5)	15(37.5)	0(0)	40
Madobi		18(45)	3(7.5)	9(22.5)	2(5)	8(20)	0(0)	40
Ajumawa		0(0)	0(0)	1(2.5)	10(25)	23(57.5)	6(15)	40
Wudilawa	Radio	1(2.5)	0(0)	0(0)	4(10)	18(45)	17(42.5)	40
Madobi		0(0)	1(2.5)	0(0)	3(7.5)	25(62.5)	11(27.5)	40
Ajumawa		4(10)	3(7.5)	3(7.5)	15(37.5)	12(30)	3(7.5)	40
Wudilawa	Print Materials	11(27.5)	0(0)	0(0)	11(27.5)	16(40)	2(5)	40
Madobi		8(20)	4(10)	12(30)	14(35)	2(5)	0(0)	40

Note: Figures in parenthesis show percentages.

Table 5. Ranking of extension methods used by extension personnel.

Extension Methods	Weighted Score	Rank Order	Mean	Standard Deviation
Farm/Home Visit	322	2	18.40	18.24
Office Calls	186	8	12.80	12.64
Demonstration Plots	269	7	17.00	12.51
Farmer Training	294	4	20.00	13.82
Local Fair	270	6	18.40	20.17
Workshop	277	5	18.00	13.87
Radio	488	1	23.80	27.25
Print Materials	302	3	19.40	15.14

Source: Calculation by author.

3. Conclusion

Agricultural extension service requires regular supervision to ensure that effective and appropriate information

is disseminated at the right time and placed to the right people. This will assist farmers achieved high income and improve living standard through agricultural production, particularly, Madobi area, where the majority of farmers (77%) have no contact with the extension service. Thus, extension should work according to farmers need and resources.

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The Development of a Data-Centred Conceptual Reference Model for Strategic GRC-Management

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Abstract

Until now there are only few ideas for an integrated governance, risk and compliance (GRC) management available with these referring to the management process of GRC only. In literature, mainly specific questions at a detailed level, like the automation of different controls, are discussed in the GRC context. To be in the position to entirely realise benefit potentials (e.g. improvement of processes), it is necessary to have an integrated GRC-Management focusing on the strategic business objectives. Starting from the requirements, this article deals with general guidelines for strategic GRC-Management showing which aspects have to be considered in terms of an integral approach. On this basis, a data-centred reference model explicates the structural connections of GRC-related data, and lays the basis for the implementation in practice.

Keywords

Governance, Risk, Compliance, Strategic Management, Information Objects, Reference Model

1. Introduction

Due to their diverse overlappings and dependences, governance, risk and compliance management [1] [2] are more and more seen as a connected topic under the acronym GRC. A study being recently carried out by the Open Compliance & Ethics Group [3] shows that the integration of GRC in practice proceeds and those companies see a possibility to improve their performance in it. Although first integrated approaches are available, [4]-[6] the borders of the topic areas remain altogether rather vague. On one hand there is a multitude of literature available concerning different sub-areas of GRC and dealing mainly with specific questions. On the other

hand there are already a few contributions available trying to structure and terminologically define GRC as an integrated approach [6] [7]. In practice, methodical weaknesses can be seen in approaches that realise individual regulatory requirements adequately, but are incapable of delivering a total overview concerning the status of GRC or the risk situation of a company. This may lead to gaps during the implementation process as well as to unnecessary double works. Moreover, governance can only then fulfill its task to support strategic decisions when adequate information is available from risk management and compliance management.

In its entirety GRC-Management cannot be limited to the aspect of integration only, but has to fulfil various requirements. The research project presented here in extracts takes—in addition to the integration of the three GRC sub-areas—the idea of a proactive and strategically adjusted GRC-Management as a basis, being referred to as “strategic GRC-Management”. Here the focus is not on operational compliance and risk control but on the extensive planning and control of the GRC status, on the integration of different GRC-aspects as well as on strategic orientation and continuous improvement.

Racz *et al.* [6] as well as the “GRC Capability Model” of Mitchell and Switzer [5] put the process of GRC-Management into the centre of their observations. The “GRC Capability Model” shows possible GRC activities, but unfortunately the model it is not differentiated in management tasks and operative activities and the integration of GRC in the individual activities is not explicitly pointed out. In addition, it remains unclear, how the approach could be integrated into existing frameworks. Finally, governance aspects are only included to a limited extent. Racz *et al.* [6] develop a process model for “IT GRC”. Here, it becomes clear that in the individual GRC disciplines a similar methodical procedure can be used, but concrete overlapping and interdependences are only dealt with marginally.

To develop a GRC-Management approach an analysis of the structural connections of the GRC-relevant information objects is necessary. The objective of this article, therefore, is the development of a data-centred conceptual reference model for strategic GRC-Management. Herewith especially two research questions are to be answered: 1) Which are the constituting information objects of strategic GRC-Management? 2) Which relations do these information objects have? The model aims to be a basis for the management of information being relevant for strategic GRC-Management. As a conclusion it can be useful as a basis for the development of GRC information systems as well as with view to the design of the GRC organisation. Furthermore, it can serve as a frame for the development of company specific models.

The article is structured as follows. In Section 2, our research method is described and linked to the field of reference modelling. In Section 3, requirements of strategic GRC-Management are outlined as they lay the foundation for our reference model. Then the model is developed, presented and evaluated. The article closes with a conclusion and some avenues for further research.

2. Foundations and Research Method

Reference models are universally applicable recommendations that can be used in a concrete modelling situation [8]. In comparison to ontologies, which as well are able to explicate the semantics of concepts and, therefore, the structure of GRC [9], reference models have the characteristic to function as a recommendation (to differentiate the terms see [10]). There are different method systems available dealing with reference modelling.

The architecture of integrated information systems (ARIS) [11] as a modelling concept differentiates between the views of organisation, of functions, of data, of results and of control/processes. Each view is looked at on the levels business concept, IT concept and implementation. In ARIS, modelling techniques are assigned to every view-level-combination. For the purpose of designing an application system the control/process view and the data view are particularly important.

We think that a reference model for GRC-Management can only be constructed on the understanding of the structure in terms of constituting GRC information objects and relations. Therefore, we focus the view of information objects and their relation in our conceptual model. The Unified Modelling Language (UML) [12] contains different object-oriented kinds of graphs showing the structure, the behavior as well as the interaction. Classification graphs are core structures of UML with the structure being focused and a specific conceptual data modelling being supported.

This contribution uses a design science research approach. Design science research aims at creating innovative and useful IT artefacts [13] [14]. These artefacts are to be evaluated w.r.t. the utility provided in solving the

addressed problem. Peffers *et al.* [1] propose a process model for the conduct of design science research that has been the basis for our own investigation. More specifically, Peffers *et al.*, integrating the views of different other researchers, propose six activities in their research methodology: identify problems and motivate, define objectives of a solution, design and develop artefact, demonstrate the use of the artefact, evaluate the results, communicate to the relevant audience.

The problem we focus on is the idea of a proactive and strategically adjusted GRC-Management. This is a relevant issue, as the approach promises benefits that are beyond operational compliance and risk control and can only be realised when one takes an integrated and strategic perspective on GRC with the aim to proactively plan and control the GRC status of the organisation as a whole. Our main objective here is the creation of a data-centred reference model [8] [15] that explicates the structural connections between the major information objects in strategic GRC-Management.

We derive the model content from the strategic GRC requirements and guidelines that were elaborated and presented in [16] and from the analysis of other models in the literature. A reference model is an example of an artefact in the sense of Hevner [13] [14]. Such a model is useful, because it lays the basis for the implementation of a corresponding strategic GRC-Management system in practice. The adequacy of the model elements and their relations is verified through an analysis of practical case studies in GRC. Finally, this paper is our attempt to communicate the findings to the relevant audience.

When it comes to modelling, the choice of the modelling technique should contain especially two aspects, being called “way of modeling” and “way of working” [17]. The first one concerns the choice of the modelling language. Here, UML classification graphs are used, as these support a specific conceptual modelling of the data and are mainly used in the models found in GRC literature. A modelling in entity relationship models [18] would be suitable, too. The “way of working” refers to the procedure of how the model is structured. Generally inductive and deductive approaches are possible for the construction of reference models.

Concerning the inductive way of working, it has to be said that reference models should be universally applicable in that sense that they should be valid for a group of company specific models [6] [8]. In an attempt to pay special attention to the requirements of reference models, the following research work combines inductive and deductive elements during the development of the reference model. A first step is the evaluation of existing models found in GRC literature, which base on empirical cases and conceptual considerations. In a second step, a comparison of the model elements found with the strategic GRC requirements, briefly outlined in the following section, takes place.

3. Strategic GRC Requirements

The basis for this research work is an extensive literature search dealing with strategic GRC-Management and on that basis the structuring of relevant aspects by means of requirements. Requirements are conditions or abilities that are needed to solve a problem, respectively achieve an objective (see IEEE glossary).

The derivation of requirements for a strategic GRC-Management was shown in [16] and will, therefore, in the following only be briefly outlined. The method of von Brocke *et al.* [19] has been adapted for the literature search, which follows the recommendation to focus on high-quality publications. In a first step, leading scientific magazines and conference proceedings were chosen with the help of relevant rankings. Furthermore GRC-specific publications were identified.

We searched in scientific databases and, in addition, manually checked the tables of contents of GRC-related journals and conference proceedings. Articles about integrated GRC approaches as well as about specific individual aspects of GRC (conceptual or empirical) were analysed. An internet search in general search engines and library databases was made, too, by which relevant works about integrated GRC approaches, publications on actual GRC practice (standards and best practices, handbooks, white papers) and relevant doctoral theses were found. All in all 191 relevant publications were found and provide the basis of our literature review.

To derive the requirements of strategic GRC-Management a qualitative content analysis was performed [20]. With the help of this analysis, categories and sub-categories of requirements were derived. The individual categories of requirements were analysed on the basis of the associated theories in the GRC-literature.

The identified requirements were then consolidated by means of guidelines that are shown in **Table 1**. The guidelines derived are to deepen the already existing knowledge and give indications in terms of high-level recommendations for the creation and further development of strategic GRC-Management approaches.

Table 1. Requirements for a strategic GRC-Management (consolidated in the form of guidelines).

Category of requirement (relevant theories)	Guidelines
Strategic orientation (market-based-view, resource-based-view, stakeholder theory, shareholder theory)	1) GRC should focus on the strategic objectives of companies to secure the companies' survivability. 2) The resources constituting the GRC-Management should support the achievement of operational potentials of benefit. To create strategic advantage through well-managed GRC, though, is at least more difficult. 3) GRC should focus on the stakeholders' interests. The stakeholders' interests should be balanced out on the premise of the long-term maximisation of the companies' value.
Integration (transaction costs theory)	4) The management activities being relevant for GRC should be carried out by a central approach (including integrated information systems and methods). The operational activities of GRC should be integrated into the core business processes and IT systems (hybrid approach). 5) To avoid double works as well as gaps during the implementation, GRC should be integrated by different compliance requirements as well as by the GRC disciplines.
Business process orientation (transaction costs theory)	6) A process oriented point of view as well as procedures, methods and tools of business process management (BPM) should be adapted to reduce the transaction costs in GRC.
Management systems (transaction costs theory, institutional theory)	7) To harmonize management systems in the context of GRC appropriate procedures, methods and tools should be developed.
Automation (transaction costs theory, principle-agent theory, organisational control theory)	8) IT should be used as an enabler for GRC-Management and be supported by appropriate organizational concepts. 9) To increase the efficacy of organisational procedures of compliance and risk control as well as for reasons of cost reduction, controls should be automated to the largest extent possible. At the same time organisational procedures should complementarily support automated controls.
Flexible business processes and IT systems (principal-agent theory, stewardship theory)	10) The challenge of flexible business processes and IT systems originates from the conflict between strategic achievement of objectives and regulatory GRC needs. This conflict of objectives should be balanced out depending on the individual situation.
Human factors (e.g. theory of reasoned action/planned behaviour, principal-agent theory)	11) The determinants of compliance behaviour are dependent on the consideration of manifold forms of control. The control approach chosen should consider the relation between the controls as well as situation specific aspects.

4. Development of the Reference Model

4.1. Evaluation of Already Existing Models in GRC Literature

In the 191 publications of interest for strategic GRC-Management, 21 relevant models could be identified (Table 2).

The evaluation of the model elements was carried out as follows. First, equal elements were assigned to each other. Then model elements using different terms but on the basis of underlying definitions have the same meaning were assigned. This includes German and English terms, respectively term variations, too. After that, the different levels of abstraction of the models were taken into account. Model elements being a subset of another element and not urgently needed for the conceptual modelling of strategic GRC-Management, were assigned to that element (e.g. "business goal" and "IT goal" to information object "goal"). Missing generic terms for matching model elements were developed. In this step, it also had to be decided, which level of abstraction or specification the model should have. Specifically this reflects the decision, whether a model element is an individual information object (classification in UML language) or just an attribute. In the end, a standardization of language was carried out. Table 3 shows the assignment of the information objects after language homogenization to the synonyms and the secondary terms resulting from the models evaluated (model numbers according to Table 2 in brackets). In addition, the number of models with elements being assigned to the mentioned information object are shown (column "No.").

For the analysis of the relations between the information objects the existing models can only be used to a small extent, as with the exception of Menzies [4] none of the models explicitly looks at an integration of GRC. But possible relations can, nevertheless, be derived. For this, on the basis of a consolidation of the model ele-

Table 2. Overview of relevant conceptual models found in GRC literature.

Model Focus	Topic Area	Source
1) Interrelationships of COBIT components	IT-Governance	[21] p. 8
2) Relationships between process modelling and control modelling concepts	Compliance	[22] p. 5
3) Selected correspondences between business process and risk	Risk management	[23] p. 24
4) Conceptual model of the compliance management problem	Compliance	[24] p. 5
5) A basic high level model for regulatory compliance	Compliance	[25] p. 180
6) Policy ontology	Compliance	[25] p. 187
7) Rule ontology	Compliance	[25] p. 188
8) A MOF/UML metamodel of a business protocol model	Compliance	[26] p. 562
9) A MOF/UML metamodel of an obligation	Compliance	[26] p. 563
10) A MOF/UML metamodel of a conditional commitment	Compliance	[26] p. 563
11) Rule ontology (constraints)	Compliance	[27] p. 794
12) The upper domain model of the internal controls compliance	Compliance	[28] p. 62
13) Relationship between an application control and a business process	Compliance	[28] p. 62
14) A semi-formalization of the control implementation	Compliance	[28] p. 63
15) IT risk reference model	Risk management	[29] p. 4
16) Meta-reference model for compliance management	Compliance	[30] p. 555
17) A classification model for automating compliance	Compliance	[31] p. 41
18) Exemplary excerpt from a corporate rule base	GRC	[4] p. 364
19) ISO 27001 metamodel	Risk management/Compliance	[9]
20) The oracle corporate analysis flow	Compliance	[32] p. 42
21) The regulatory mandate and compliance framework control domain relationship	Compliance	[32] p. 43

ments, relations within the models were identified, while the following restrictions apply. The focus, respectively the level of abstraction of the model in question has an important influence on the relations in the model. For instance, in the models evaluated the information object “role” (representing responsibility) has a relation to almost every other information object. In our case especially the responsibility for the GRC controls and business processes is relevant.

If no differentiation between the individual information objects in a source model was given, several relations were included. For instance, the information objects “control objective” and “control” were both put in relation to “business process”, as there is not always a differentiation between the two in the literature. Partly, the source models differ in focus (company-wide vs. IT-related models), which had to be accounted for when transferring relations between information objects to the reference model.

Generally, it was not tried to show every possible relation, but to focus on those which lead to a consistent model and are very widespread. To achieve this, especially the analysis of strategic GRC requirements has made its contribution. Within the context of the presentation of the reference model (Section 5), the analysis has been seized in such a way that the relations identified in the already existing models are referenced at relevant passages to give reasons for the relations in the conceptual reference model developed.

4.2. Relation of Model Objects with Strategic GRC Requirements

In the following, the information objects for the reference model are derived from the requirements of strategic GRC-Management (as outlined in Section 3). **Table 4** summarizes the results.

Strategic orientation: The strategic orientation requires the orientation of GRC towards business strategies, the consideration of possible conflicts of objectives between the fulfilment of norms and the strategic achieving of objectives, the pursuance of potential benefits and the orientation towards stakeholders [16]. So information objects like “strategy”, respectively “goal” are activated. GRC, meaning specifically the control objectives, should according to this be oriented towards the business goals. Governance should provide a framework for the

Table 3. Structured overview of model elements.

Information Object	Synonym Terms (As Used in Literature)	Secondary Terms	No
Control	Control Practices (1), Internal Control(s) (2, 5), Rule (4, 18), Procedures (5), Business Rule (11), Control (12, 19), Business Rule (20)	Risk Treatment Measure (3), Operational Business Rule (11), Declarative Business Rule (11), Company Level Control (12), IT Control (12), Application Control (12)	14
Role	Responsibility and Accountability Chart (1), Person Profile (3), Organisational Unit (3), Functional Entity (3), Actor (4), Business Function (6), Agent (11, 13), Authority (13), Organisational Chart (16), Responsible (18)	N/A	12
Business Process	Process (2), Process Model (6)	IT Processes (1), Key Activities (1), Task (2), Enterprise Activity (3), Process Structure (3), Activity (4, 6, 13), Process Fragment (6), Process Construct (6), Operation (11)	12
Control Objective	Requirement (4, 18, 19), Rule Goal (7), Measures & Directives (16), Directive (20)	Application Control Strategy (13, 14)	11
Guideline	Policy(ies) (4, 6, 11, 17), Standard Operating Procedure (18), Business Policy (20)	Meta-Policy (6)	7
Risk	Risk (2, 3, 4, 11, 12)	Event (3), Vulnerabilities (15), Threats (15, 19)	7
GRC Requirement	Source (4), Regulation (5, 6, 20), Authority (11), Laws and Regulations (17, 18)	N/A	7
Resource	Asset (3, 19), Enterprise Object (3), Business Subject (Sub-subject) (4), Subject (6)	Product Group (18)	5
Goal	Objective (3, 20), Desired Result (20)	Business Goals (1), IT Goals (1)	5
Application Area	Domain (3), Jurisdiction (6), Scope (6, 7), Scope (14)	Control Domain (21)	5
Documentation	Business Protocol (8), Business Document (13), Document Model (16)	N/A	5
Assessment	Audit (17)	Control Outcome Tests (1), Control Design Tests (1), Risk Assessment (12)	4
IT Component	IT Applications/IT Infrastructure (15, 21), IT-Architecture Model (16), Database Model (16), IT-System (17)	Packaged Service (21)	4
KPI	Performance Indicator(s) (1, 3)	Risk Indicator (3)	3
Stakeholder	Stakeholder (3, 18)	Indirect Stakeholder (18)	2
Strategy	Strategy Model (16)	N/A	2
Maturity Level	Maturity Model (1, 16)	N/A	2
Framework	Compliance Framework (21)	N/A	2
Performance	N/A	N/A	2
Monitor	N/A	N/A	2
Violation	N/A	Security Breach (19)	2
Implementation Logic	Rule Logic (7)	N/A	1

definition of strategy and goals and make the integrated management of “performance” and “conformance” [33] possible by means of assessments and key performance indicators. Better controls may lead to the improvement of the business process performance and to the achievement of business objectives by means of GRC, being equivalent to the requirement to pursue potential benefits. The stakeholder orientation requires an alignment of the strategy and of the goals and by this indirectly an alignment of the control objectives to the interests of the stakeholders.

Integration: The integration of GRC is discussed in literature with view to content-related, methodical, re-

Table 4. Information objects and relations from the requirements of strategic GRC-Management.

Category of requirement	Relevant information objects	Derived relation
Strategic orientation	Strategy, Goal, Guideline, Control, Key Performance Indicator, Stakeholder	(B1) Control objectives are adjusted to the goals.
		(B2) Business processes support goals being measured by key performance indicators.
		(B3) Strategy and goals are oriented on stakeholders.
		(B4) Control objectives result from risks and GRC requirements.
Integration	Control Objective, Risk, GRC Requirement, Key Performance Indicator, Assessment, Business Process, Control	(B5) Assessments measure through performance indicators conformance and performance of business processes.
		(B6) Controls are realised during core business processes (operative integration).
		(B7) Controls are implemented into business processes and with the help of an implementation logic are automated within the business process.
Business process orientation	Control, Business Process, Implementation Logic, Role	(B8) The responsible role (ownership) is determined by business processes.
		(B9) Business processes are controlled by assessments and through key performance indicators with view to GRC.
Management systems	Assessment, Key Performance Indicator, Business Process	(B10) IT components are directly affected by controls.
Automation	Control, Business Process, IT Component, Implementation Logic	(B11) Controls are automated by an implementation logic.
		(B12) A direct relation between IT components and risks is necessary to make a control of the risks during IT-related adjustments possible.
Flexibilisation	All, especially Business Process, IT component, GRC Requirement, Risk	
Human factors	Control, Business Process, Role	(B13) Controls have a direct relation to the information object “role”.

spectively information technical aspects. Content aspects are the integrated fulfilment of several GRC requirements and the integration of GRC disciplines. In addition, an integration of GRC-activities into core business processes is demanded [16]. For the research objective pursued by this reference model, both integration aspects are highly relevant. There are two points of views concerning the relation of compliance management and risk management. On one hand, compliance is seen as a sub-area of risk management, in which the non-compliance-risk is considered as a risk category [34] [35]. On the other hand, risk management is seen as a sub-area of compliance. Risk management and in relation to that the establishment of an internal control system, therefore, is a GRC requirement, its realisation being supported by control models like the ones used for IT processes, e.g. COBIT, ITIL or ISO 27001/2 [36]. But it is also possible to define control objectives for risk controlling measures out of risk analyses. Control objectives, therefore, can be derived from risks as well as from GRC requirements.

Concerning the obeying of regulatory requirements [2] there is an overlapping between corporate governance and compliance. In addition the term corporate governance is associated with a value-based leadership strategy of companies [2] which is backed up by the IT governance term as well [30]. According to Racz *et al.* [6] corporate governance as well as risk and compliance management support themselves mutually by delivering important information from risk and compliance management to governance and by taking over the control of risks and compliance management by governance.

Business process orientation: In the literature a business process-oriented approach is demanded due to the importance of business processes for GRC as well as the importance of a business process-oriented approach for the automation of compliance safe-guarding [16]. This results in the demand to integrate GRC and business process management. Business processes have a direct connection to risks [29] and in terms of an operative integration (see requirement category “integration”) should include the controls. As business processes are the starting point of automation, there is also a relation to the implementation logic. Following a business process-oriented approach, the business process is a central element of GRC-Management. The responsibility (ownership, information object “role”) for business processes, thus, determines ownership to a number of further in-

formation objects, such as “controls”, and, consequently, the responsibility for the fulfilment of GRC-requirements. Risk minimizing measures should be carried out by the employees working within the associated business process.

Management systems: A harmonization of GRC with other management systems in the company is required, as today GRC contents are often distributed over several organizational units and management systems. Relevant management systems that have to be coordinated with GRC are those that can be subsumed under a certain GRC topic area (e.g. internal revision, data protection, quality management) and others that in the context of GRC are more generally relevant (e.g. controlling, IT management) [37] [38]. Management systems being subsumed under GRC mainly deal with the control of the spheres of responsibility they were entrusted to. This is very much underlined in the scope of tasks for the internal revision, providing independent control and council services [39]. Controlling has a similar task, which supports the management by planning, controlling and the provision with information and uses performance measurement systems. It must be pointed out that adjustment and coordination of GRC with related management systems generates costs that could partially be avoided with a more centralized GRC-approach.

Next to business process management also IT management concerning the introduction and operation of information systems and quality management as well as the internal revision often pursue business process-oriented approaches. As a conclusion, next to “assessments” and “key performance indicators” also “business processes” are relevant information objects here.

Automation: IT is object and supporter of GRC [2]. From the point of view of IT as a supporter of GRC, especially the automation of compliance safeguarding and of risk control is relevant. Thereby, the manual control effort and risk of human errors are reduced. IT as an object of GRC, respectively in the context of information security, is directly an object of compliance requirements and risks. Relevant information objects are “controls”, “business processes”, “IT components” and “implementation logic”. In addition, not every control can be automated, but partly has to be carried out manually [29].

Flexibilisation: In literature flexible business processes and IT systems are presented as a grand challenge for GRC. Consequences of regulatory changes to the organisation, respectively effects of organisational adjustments on compliance have to be looked at [40]. Furthermore, it is necessary to supervise continuously the risks [31]. Menzies [4] identifies pushers of GRC-management such as new processes and products, M & A activities and IT systems.

Flexibilisation may have consequences to nearly all information objects of the reference model, especially to “strategies”, “goals”, “business processes” and “resources”, “risks” as well as “controls”. Sackmann [31] puts emphasis on the relations between risks and IT components as well as business processes. The direct relation between IT components and risks is necessary, as changes among the IT components may have direct consequences for the risk situation, which do not necessarily affect the running of business processes.

Factors concerning human behaviour: The demand to consider human behaviour refers to the behaviour of employees [41] [42], the company culture [5] [43] as well as the communication in terms of the “tone at the top” [4] [5] [35]. The responsible employee who in his position carries out business processes and the controls included, is therefore of high importance. For this reason, controls such as trainings and awareness campaigns should be offered to make employees competent for their roles in GRC and to encourage them. As a conclusion, “controls” have a direct relation to the information object “role”.

5. Presentation of the Reference Model

The reference model shown in **Figure 1** bases on the analyses made in the sections before. In addition, the presentation already anticipates the results of the evaluation in Section 6. Information objects that could not be confirmed during evaluation are left out. The relations between the information objects are derived by the already existing models (1 - 21, according to **Table 2**) as well as by relations derived from the strategic GRC requirements (No. B1 - B13 according to **Table 4**). Due to the complexity of the model, a further subdivision into a strategic, conceptual and operative level has been made, which only is to improve the readability of the model and is not subject of the derivation, respectively evaluation.

On the strategic level, GRC should start at the results of strategic management, use these for governance and for the strategic orientation of risk and compliance management and furthermore support the strategy process by means of relevant information. Starting point are the stakeholders whose interests have overall economical in-

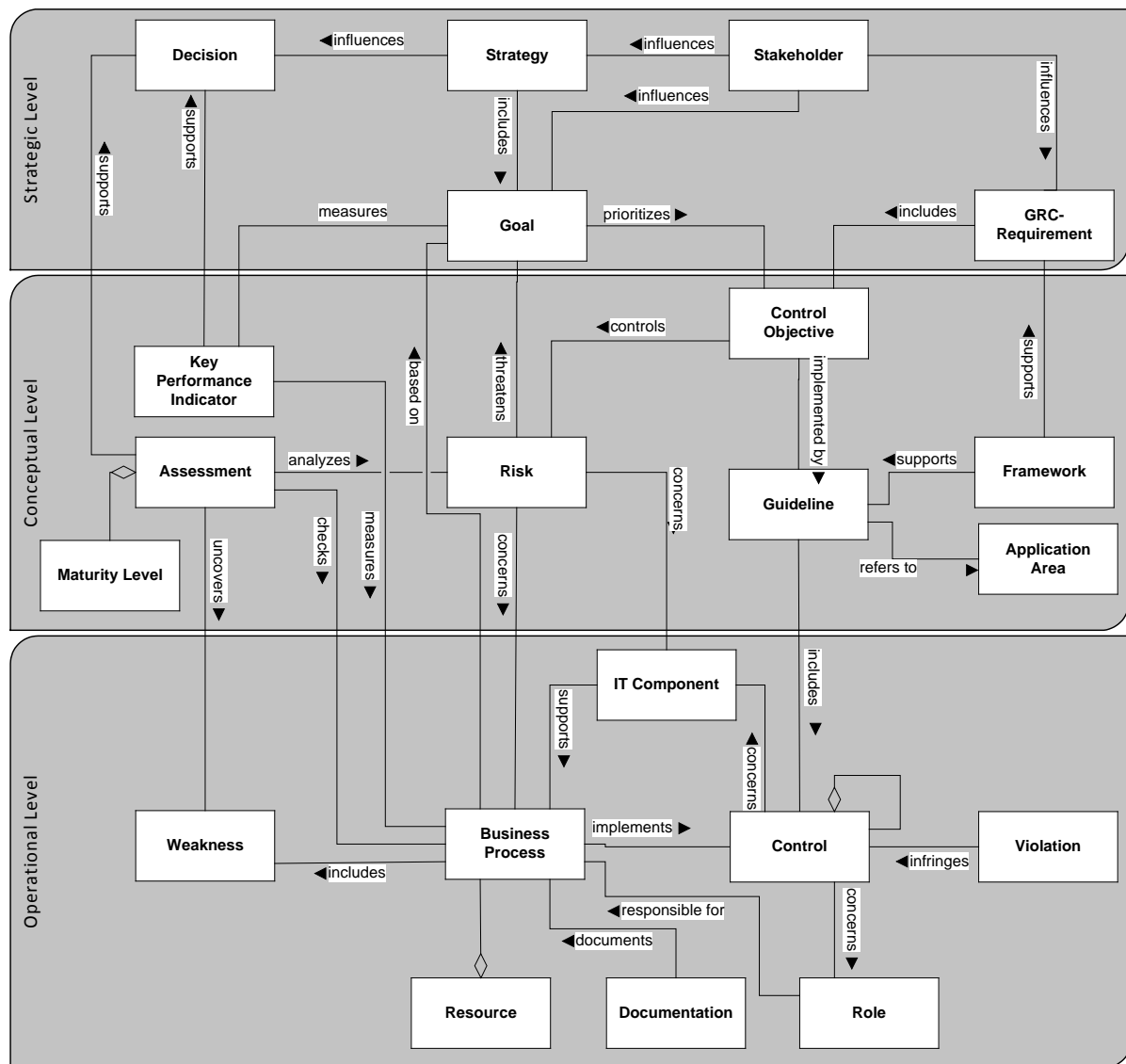


Figure 1. Data-centred conceptual reference model for strategic GRC-Management.

fluence on the GRC requirements (18) and company-related, as shown in the analysis of the requirement category “strategic orientation”, have influence on strategy and goals (B3). Strategies support the achievement of objectives (6, 16) and influence the decision-making (see evaluation).

It should be differentiated between the strategic level and the conceptual level, which includes the management activities of GRC. Here the control objectives resulting from the GRC requirements (4, 5, 17, 18, B4) and the risks (2, 4, 12, B4) have to be developed. The requirement category “strategic orientation” also suggests that the control objectives should be adjusted to the business goals of the strategic level (1, B1). The guidelines are derived from the control objectives (4, 5, 17, 18, 20), which have a limited application area (6).

To derive company-specific guidelines, frameworks like established standards and best practices can be taken (4, 18), which support the fulfilment of GRC requirements (18). Business processes have to be adjusted to company goals (3, 20, B2, B9). The focus of this model suggests to carry out assessments with view to risks (12) as well as to “conformance” and “performance” (B5) on the business process level (1, 12, B5, B9). In this context, maturity models can be used, which are a special form of assessment. Assessments support decisions on the strategic level. Business processes are again connected to controls (2, 3, 5, 6, 11, 12, 13, 18, B6, B7) and risks (3, 12, 15, 19). Risks still can result directly from IT components (15, B12) without business processes being

changed. Risks threaten the achievement of objectives (11). Performance indicators measure business processes (1, B5, B9) concerning the achievement of goals (1, 3, 16, B2) and herewith support, as well as assessments, decisions on the strategic level (see evaluation).

On the operative level, controls being formulated in the form of guidelines (4, 5, 6, 11, 18, 20) are implemented in terms of an operative integration into the core business processes (2, 3, 5, 6, 11, 12, 13, 18, B6, B7). There may be dependencies between the controls themselves (6, 11, 19). Controls still can be infringed by violations (4, 19) and, next to business processes, directly concern those IT components (B10) which support the business processes (15). In addition, IT components serve for the automation of controls (B11). Business processes are seen as company resources, whereby further objects like products, projects and information are relevant for GRC (3, 6, 18). IT components and controls have to be documented within the context of business processes (13). The model defines the responsibilities by means of the roles being part of the business processes (1, 4, 6, 11, 13, 18, B8). Controls may directly concern employees (11, B13). Eventually, weaknesses of business processes can be found within the context of assessments on the conceptual level (see evaluation).

6. Evaluation

It is possible to evaluate reference models with view to different criteria like e.g. the principles of modelling [44] and by using different methods of evaluation [45]. Here the usefulness of the reference model during the data modelling process for a strategic GRC-Management is to be evaluated. This includes the adequacy of the information objects, e.g. with view to the level of abstraction and the terms used, the completeness of the information objects and the correct modelling of the relations between the information objects. Furthermore, it is planned to further specify the information objects with view to practice requirements e.g. by attributes. As until now the GRC integration on the strategic level has been rarely looked at by research [46], practical case studies found in literature dealing with GRC sub-aspects were taken for evaluation. These refer to successful implementations and make it possible to integrate a relatively broad range of cases with a sufficient depth of content. Further evaluations, e.g. concerning the correct syntax, and an application of the model in practice are desirable. However, the success of the application depends also on further factors such as the maturity of the business process management of the company, the availability of appropriate GRC-Management methods and the information systems used.

The procedure of evaluation is as follows. First, implementation examples were identified by looking for case studies in the literature [16] and through the search in general search engines as well as practical publication organs. Altogether 21 relevant practical examples were included and used for evaluation.

On a general level, the evaluation shows that a standardised GRC-terminology is missing in practice. Partly different terms for the same matters are used, respectively differentiated only insufficiently from each other. In the case studies, differences between the GRC sub-areas and industries with reference to the information objects could hardly be found. Rather, common core terms such as “control”, “business process”, “risk” and different terms dealing with GRC requirements were found. Due to the great significance of the Sarbanes-Oxley-Act across all business fields, financial reporting on the whole is of high importance. The involvement of the top management into many GRC-tasks is still seen as important. Explicitly, the uncertainty concerning the management methods for GRC was pointed out [4]. Frameworks such as COSO and COBIT were judged to be too abstract and cannot always clearly be distinguished from the actual regulatory GRC requirements.

As far as adequacy and completeness of the information objects are concerned, **Table 5** shows the number of practice examples using terms that can be assigned to the information objects of the reference model. The result is an overlapping and a similar distribution of terms as in the evaluation of the existing GRC-models in literature. But it has to be said that none of the examples confirms all information objects. The models found in GRC literature have often been developed with the objective of automating controls, which is not at the centre of the practice examples. The information objects “monitor” and “implementation logic”, therefore, could not be confirmed. The information object “execution” was only confirmed in one case and is, thus, merged with “business process”.

The level of abstraction of the reference model seems to be appropriate, but needs further specification concerning the shaping of the attributes of the information objects. Controls are relevant on different levels and are differentiated into company level, business and IT controls [4]. In addition, the focus in practice is put on key controls with the objective to achieve a concentration towards critical areas. Business processes are mentioned

Table 5. Information objects and number of practice cases in support.

Control	16
Role	16
Business Process	21
Control Objective	13
Guideline	11
Risk	1
Resource	2
Goal	11
Application Area	5
Business Document	15
Assessment	13
IT Component	14
Key Performance Indicator	7
Stakeholder	6
Strategy	9
Maturity Level	3
Framework	7
Execution	1
Monitor	0
Violation	2
Implementation Logic	0

in every example including also management processes of GRC. The processes are divided into core and supporting processes in the practice examples, responsibilities are relevant on all hierarchy levels. Business documents are cited concerning the documentation of controls and the reporting system. It is proposed to classify risk into risk categories [47]. The examples show that financial performance indicators for profitability and costs are of importance for GRC. The value respectively the value creation of GRC is relevant as well.

A number of further terms are of high relevance in the practice examples, but cannot directly be assigned to the information objects in the reference model and, therefore, are discussed here in more detail. Terms like “group”, “division” and “national company” show the complexity of international groups. The reference model is basically able to show this by means of several models on different levels of hierarchy. The term “project” in the examples refers to projects dealing with the realisation of GRC requirements. But also business initiatives, especially in the IT sector, are realised by means of projects and are, hence, object of GRC-Management.

A number of case studies mention the carrying out of trainings, which are a kind of control having a direct relation to the information object “role”. The term “control” is of high importance in the examples. It refers to the term “governance” and shows the task of GRC concerning the management of “performance” and “conformance”. Several times the term “weakness” is mentioned, which is used in the sense of weakness in control and has to be added to the reference model. Further terms being cited in connection with financial reporting are “financial data” and “account”. Both terms are objects of control and are subsumed under “resources” in the reference model.

GRC has the function to support decisions on the strategic level. To support decision making, especially information coming from assessments and performance indicators is relevant. Also a meeting structure, which includes a management board responsible for decision-making, is necessary. Therefore, “decision” is added to the model as an information object. The terms “service level agreement” and “service” are cited, too, but are especially of relevance for IT governance and were not taken over into the generic reference model. They point out the importance of services as a subject of controls and the importance of contracts as a source of GRC requirements.

With respect to the relations of the information objects, it can be stated that relations are rarely looked at in the practical case studies and their analysis is further complicated by an inexact terminology. For instance, several times scoping is mentioned (information object, application area), but it is not clear, whether this refers to GRC requirements, control objectives, controls, risks or GRC guidelines. Partly, the relations themselves are described very generally. For instance, departments are to be oriented towards goals [48].

Only the practice example in [49] discusses explicitly the integration of GRC, but does not focus on the information level but on organizational structures and reporting. The difference between the information objects “control objective” and “control” is not explicitly made clear in all practice examples. Therefore, controls like e.g. in [4] are not always assigned to the control objectives, but partly directly to risks. Relations between controls [4] [50], controls and processes [4], risks and objectives [47] as well as processes and assessments [48] [51] are confirmed in the practical cases.

7. Conclusions

In this article, a data-centred conceptual reference model for a strategic GRC-Management was developed, which shows the relevant information objects and structural connections. Only insignificant adaptations and a few indications for further specification of the model resulted from the practice-based evaluation of case studies in the literature. The kind of evaluation chosen seems appropriate, as the research concerning GRC integration is in its infancy. Moreover, the examples we looked at have a sufficient depth of content.

However, the evaluation of the relations between the information objects was only possible to a limited extent by means of the case studies. Although a reason for the connection of the model elements was given by the models found in literature and by the strategic GRC requirements, the relations should be subject of further research.

The objective of the research project presented here was the development of a specific conceptual reference model. To implement it in the context of an information system for strategic GRC-Management will require further refinement, such as adding attributes to the information objects. Moreover, it makes sense to further specify the information objects following the organizational company hierarchy in big groups. More research needs still exist, e.g. with view to the applicability of the model in different lines of business.

Finally, it can be said that by the majority of the case studies evaluated still a great uncertainty became visible concerning the realisation of GRC approaches. The GRC requirements found within the context of our examination, the guidelines and the reference model, which aims at the data level, represent only first steps towards the strategic alignment and integration as well as towards the terminological standardization of GRC. Herewith, the implementation of a strategic GRC-Management in companies is supported. But with view to the management methods and IT-based tools in GRC-Management, deficits can be identified that will have to be solved in future research projects. The reference model may give important indications to companies to better classify methods and tools, to choose them accordingly or, if needed, to develop them themselves.

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On Real-Time Accounting of Inventory Costs in the Newsvendor Model and Its Effect on the Service Level

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Abstract

The newsvendor model is the cornerstone of most periodic inventory models; however, it distorts the correct timing of inventory costs and thus misses the optimal solution of the inventory system. This work presents a modification of the classical newsvendor model that considers the holding cost according to the stock-levels within the selling period rather than according to the stock-level at the end of it. The selling period (for example, a season) is divided into equal-time epochs (for example, one-day epochs), where demands are not necessarily identical across epochs or independently distributed. A mathematical model is formulated to find the optimal order quantity which maximizes the expected profit. We show: 1) that the profit function is concave; 2) that the structure of the optimality equation is similar to that of the classical newsvendor model; 3) how to attain the real tradeoff between the expected profit and the service level. Finally, we propose three heuristics to approximate the optimal order quantity and two bounds on its value, which are easy to implement in practice, and evaluate their performances using extensive numerical examples in a factorial experimental design.

Keywords

Newsvendor, Service Levels, Accounting

1. Introduction

In contrast to deterministic demand models, such as the economic order quantity (EOQ), which assume continuous accounting of inventory costs, most stochastic periodic-review inventory models assume that inventory costs are calculated according to the inventory level at the end of the replenishment period. For example, the

newsvendor problem assumes only overage and underage costs (denoted c_o and c_u , respectively) and the optimal policy is obtained when the probability of not stocking out in a review cycle (a probability referred to as the type 1 service level) is equal to $c_u / (c_o + c_u)$. It seems that developers of stochastic models use this cost accounting approach as a means of increasing their models' mathematical tractability. However, when the period is not short, this accounting approach might lead to substantial loss, as is shown by Rudi *et al.* [1].

Only recently have stochastic periodic review models been modified to consider the real times at which inventory costs occur within each period. Rao [2] analyzed the long-run average cost in a periodic review (R, T) model with backlogging, in which inventory-related costs accrue in continuous time. Rudi *et al.* [1] dealt with a similar problem and suggested an approximation formula for the optimal order-up-to level when the period length is given and demand is a Brownian motion process. Shang and Zhou [3] and Shang *et al.* [4] analyzed a full backlogging serial inventory system with inventory costs that accrue at evenly-spaced points within the period. To minimize the average cost per period they suggest a heuristic procedure based on calculating lower and upper bounds for the cost function.

The four papers above deal with a multi-period model and share few underlying assumptions: full backlogging of unsatisfied demand and no spoilage; holding and shortage costs that are only duration-dependent; and stationary demand process within the period. For example, Rudi *et al.* [1] show that, in a full backlogging system in which both holding and shortage costs are accounted for continuously, the optimal policy is obtained when the fill rate (referred to as the type 2 service level) is equal to $c_u / (c_o + c_u)$. However, this result does not hold in the case of lost sales, in which only the holding cost is duration dependent, whereas the cost of a stock-out predominantly depends on the stock-out quantity. This case is applicable to perishable items such as fresh food and fashion items, which are mostly analyzed under the assumptions of deterministic demand and forbidden shortages (see, e.g., Avinadav and Arponen [5]; Avinadav *et al.* [6], Avinadav *et al.* [7]; Herbon [8]; Dash *et al.* [9]).

The current research seeks to explore how the two different approaches to inventory cost accounting affect the solution of a periodic review model with stochastic demand. To this end, we use the classical newsvendor problem as a benchmark (Arrow *et al.* [10], Hadley and Whitin [11]), reformulate it, and solve it according to the real-time holding cost accounting within the period. Our approach, which is demonstrated in the following sections, can be extended to more elaborate periodic review inventory models, such as multi-period models with partial backlogging and spoilage, and to include lead time, duration-dependent shortage cost, fixed order cost and non-stationary inventory costs within the selling period.

The selling period is split into several equal-time epochs (see also [3] and [4]) according to the minimal duration in which holding costs accrue (e.g., a business day, a week, etc.). The approach of splitting the selling period into epochs was previously suggested by Sen and Zhang [12] as a means of considering multiple demand classes, and by Chung *et al.* [13] as a means of allowing for in-season price adjustments. A common assumption, which is also assumed here, is that unsatisfied demand is lost, so that shortage leads to a loss of profits, which depends only on the stock-out quantity (and not on the duration). Actually, such a model was suggested as a direction for future research by Rudi *et al.* [1], who analyzed a full backlogging inventory system, and it is applicable to many inventory systems of perishable items, such as supermarkets and fashion stores.

Although the selling period is divided into epochs to handle holding costs correctly, we assume that inventory cannot be replenished within the period, even when inventory is exhausted. This assumption is fundamental in all periodic review models and is valid for several reasons, such as fixed replenishment dates dictated by the supplier/producer (e.g., in food products) and lead-time (including production time) that is equal to or greater than the selling period (e.g., in fashion stores). In contrast to the models in [1] [4], in which an assumption of stationary demand process is essential, our model allows for non-stationary demand. Relaxation of the assumption of stationary demand is important in order for our model to be applicable to the case of perishable items, which are characterized by deteriorating demand within their selling period due to loss of freshness and customers' preference for fresh items (see, e.g., [5]–[8]). Typically, in order to free up space for new or fresh items, vendors of perishable items sell all leftover units at salvage value at the end of the selling period or even distribute them for free to save scrap costs (see, e.g., Cachon and K  k [14]). Accordingly, we analyze examples in which the expected demand in each epoch is not greater than that of its predecessor epoch. This is an extension of the deterministic negative time-effect within the selling period, used in [5].

The main achievements of this study are 1) formulating the expected profit function for real-time holding cost accounting (in Section 2); 2) showing that the expected profit function is concave, formulating the optimality

equation as the classical newsvendor formula with modified demand distribution and cost parameters, and suggesting a search algorithm to obtain the optimal order quantity (in Section 3); and 3) suggesting simple heuristics to obtain the optimal order quantity and bounds on its value (in Section 4), and evaluating their performance (in Section 5).

2. Model Formulation

We assume the standard assumptions of the newsvendor problem, where unsatisfied demand results only in loss of profit, and overage units are sold at salvage value to a secondary market. Regarding the main feature of the model, division of the selling period into epochs, we assume that the cost of holding a single item in stock is constant across epochs. On the other hand, we do not assume that demands across epochs are independent or identical. We develop the model for discrete demand to allow a point mass probability of zero demand (which characterizes inventory systems with small demand rates), and to support our numerical examples (Section 5), which assume a Poisson demand process (as is common in the literature). Extension to more elaborate models of the newsvendor problem is not complicated, and is specifically simple for models with continuous demand and with duration-dependent shortage costs.

In the rest of this paper we use the following notations:

n = the number of epochs in which holding costs are accounted for during the selling period.

d_k = the demand in the k^{th} epoch.

D_k = the cumulative demand in the first k epochs ($D_k = \sum_{i=1}^k d_i$).

$P_k(\cdot)$ = the probability function of D_k .

$F_k(\cdot)$ = the cumulative distribution function (CDF) of D_k .

μ_k = the mean of D_k .

σ_k = the standard deviation of D_k .

Q = the quantity of an order, which is the decision variable.

I_k = the stock level after the first k epochs ($I_k(Q) = \max\{Q - D_k, 0\}$).

I = the total stock during the selling period stored for an epoch ($I(Q) = \sum_{k=1}^n I_k(Q)$).

h = the holding cost of an item for an epoch.

c = the purchasing cost of an item from the supplier.

r = the retail price of an item within the selling period ($r > c$).

s = the salvage value of an item at the end of the selling period ($0 \leq s < c$).

π = the expected net profit, which is the objective function.

The expected profit from selling units is a function of three elements: purchase cost, revenue, and stock holding costs. Our formulations of the first two elements do not diverge from those of the standard newsvendor model: the purchase cost is cQ , and the expected revenue, which includes revenue from units that are sold within the selling period, as well as the salvage value of the remaining units, is

$$\begin{aligned} REV(Q) &= \sum_{j=0}^Q (rj + s(Q-j)) P_n(j) + rQ \sum_{j=Q+1}^{\infty} P_n(j) = (r-s) \sum_{j=0}^Q j P_n(j) + sQ \sum_{j=0}^Q P_n(j) + rQ \sum_{j=Q+1}^{\infty} P_n(j) \\ &= sQ + (r-s)(\mu_n - \eta_n(Q)) \end{aligned} \quad (1)$$

where

$$\eta_k(Q) = \sum_{j=Q+1}^{\infty} (j-Q) P_k(j) \quad (2)$$

is the expected shortage during the first k epochs. The expression on the right-hand side of Equation (1) can be explained as follows: all purchased units yield a guaranteed revenue per unit that is equal to the salvage value s , where the expected sales volume during the entire period (expected demand less expected shortage) yields additional revenue per unit beyond the salvage value $(r-s)$.

The expected total stock over the whole period is

$$E[I(Q)] = \sum_{k=1}^n \left[\sum_{j=0}^Q (Q-j) P_k(j) \right] = \sum_{k=1}^n [Q - \mu_k + \eta_k(Q)]. \quad (3)$$

Note that $E[I(Q)]$ replaces the commonly used “end-of-period” stock calculation, according to which the expected total stock is $E[I_n(Q)]$. Finally,

$$\pi(Q) = REV(Q) - cQ - hE[I(Q)] = (r-s)(\mu_n - \eta_n(Q)) - (c-s)Q - h \sum_{k=1}^n (Q - \mu_k + \eta_k(Q)). \quad (4)$$

Equation (4) fits also the continuous demand case, and as shown in Appendix A, it is a generalization of the classical newsvendor profit function, which is obtained by substituting $n = 1$ and $s = 0$.

3. The Optimal Order Quantity

The profit function in the classical newsvendor problem is known to be concave (Hadley and Whitin [11], p. 299). The following lemma shows that this property is also valid in our model. Let $\Delta\pi(Q) \equiv \pi(Q+1) - \pi(Q)$ be the difference equation of the profit.

Lemma 1. $\Delta\pi(Q)$ is non-increasing in Q .

Proof. By Equation (2),

$$\eta_k(Q+1) - \eta_k(Q) = - \sum_{j=Q+1}^{\infty} P_k(j) = F_k(Q) - 1,$$

so that, by Equation (4),

$$\Delta\pi(Q) = r - c - (r-s)F_n(Q) - h \sum_{k=1}^n F_k(Q). \quad (5)$$

Since $F_k(Q)$ is non-decreasing in Q , then $\Delta\pi(Q)$ is non-increasing in Q .

Let Q^* be the optimal order quantity. Then, by Lemma 1, we state

Theorem 1. $\pi(Q)$ is concave and Q^* is the smallest integer Q that satisfies

$$(r-s)F_n(Q) + h \sum_{k=1}^n F_k(Q) \geq r - c. \quad (6)$$

Dividing Equation (6) by $r - s + nh$, Q^* is the smallest integer Q that satisfies

$$F_X(Q) \geq \frac{c_u}{c_o + c_u}, \quad (7)$$

where $F_X(Q) \equiv \sum_{k=1}^n w_k F_k(Q)$, $w_k = \frac{h}{r-s+nh} > 0$, $k = 1, 2, \dots, n-1$, $w_n = \frac{r-s+h}{r-s+nh}$, $c_u = r - c$ and

$c_o = c - s + nh$. Since $\sum_{k=1}^n w_k = 1$ then, according to Chatfield and Theobald [15], F_X is the CDF of a mixture (of random variables).

Actually, the random variable X can be considered as the demand over a subinterval of the selling period; this subinterval starts at the first epoch, and its length (in epochs) is a random variable over the support $[1, n]$ with probabilities that correspond to the cost ratios w_k , $k = 1, 2, \dots, n$. Thus, by Equation (7), we conclude that considering the real-time holding cost accounting within the selling period results in the classical newsvendor optimality condition (Nahmias [16], p. 244) with modified demand distribution and cost parameters. Specifically, the mixture X replaces the demand over the entire period, D_n ; c_u denotes now the maximal loss of profit due to lost sales (as if all sales take place immediately at the start of the selling period such that sold stock does not accumulate holding costs); and c_o denotes the loss due to selling a unit at salvage value plus the holding cost incurred from holding the unit in inventory for the entire selling period.

Analytical extraction of Q^* is intractable for most demand processes, including stationary ones. This situation is not uncommon in the classical newsvendor problem as in many cases there is no analytical expression for the inverse CDF of the demand over the entire selling period (e.g., for the Poisson distribution). Due to the monotonicity of any CDF, the value of Q^* can be found using efficient line-search algorithms, such as the bisection search (Bazaraa *et al.* [17]) adjusted to integers.

Since demand is a nonnegative random variable, it is clear that $P(D_k > Q) \leq P(D_{k+1} > Q)$, $k = 1, 2, \dots, n-1$,

for all Q (i.e., the probability that demand exceeds a certain value during a given interval of time is not greater than the probability that it will exceed that value during a longer interval of time). According to Whitmore and Findlay [18], D_{k+1} stochastically dominates D_k , denoted by $D_k \prec D_{k+1}$. Then, by the definition of $F_X(Q)$, we state

Theorem 2. $X \prec D_n$ (i.e., $F_X(Q) \geq F_n(Q)$).

Since the optimal order quantity in the classical end-of-period accounting approach is $F_n^{-1}(c_u/(c_o + c_u))$ and that under the real-time accounting is $F_X^{-1}(c_u/(c_o + c_u))$, then, by Theorem 2.

Corollary 1. Disregarding the real-time of holding cost accounting leads to a higher-than-optimal order quantity.

The Relation between the Expected Profit and the Service Level

Disregarding the real-time of inventory cost accounting can also affect firms in which the service level is important. Examples for such firms are non-profit organizations, which operate on the basis of budget, and firms in which stock-out may cause long term reduction of demand. The relation between the expected profit and the service level is illustrated in Figure 1. The expected profit is a concave function of the quantity ordered, attaining its maximum at $Q^* = F_X^{-1}(c_u/(c_o + c_u))$, whereas the service level is an increasing function of the quantity ordered. Specifically, any attempt to increase the type 1 service level above $F_n(Q^*)$ causes a decrease in the expected profit. Accordingly, the firm decides on the order quantity while considering the tradeoff between decreasing the expected profit and increasing the service level. Using the classical end-of-period accounting, the firm does not observe the real tradeoff (due to incorrect profit function). For each given service level the firm observes an expected profit that is higher than the real one, so that a wrong decision on the quantity ordered might be inevitable.

4. Heuristic Order Quantities

For practitioners, a search procedure to obtain the optimal order quantity in each replenishment period might not be an efficient option, given that inventory systems may hold numerous items, whose cost and demand parameters are likely to change across periods. For such cases we develop heuristic solutions that can be calculated with a simple formula. These heuristic solutions are based on the classical newsvendor formula with adjusted demand distribution or inventory costs. Moreover, these heuristics are also applicable when only partial information on the demand process is available, as discussed in 4.3.

4.1. Bounds of Q^*

Simple and intuitive upper and lower bounds on the optimal order quantity can be based on concentrating the entire demand in the first epoch and in the last epoch, respectively. When the entire demand is concentrated in

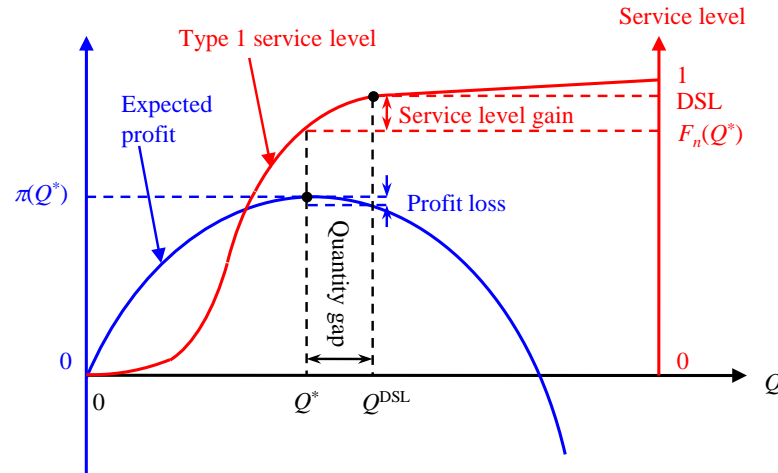


Figure 1. Illustration of the relation between the expected profit and the service level (DSL denotes the desired service level).

the first epoch, $F_k(Q) = F_n(Q)$ for $k = 1, 2, \dots, n-1$, and the optimality condition in Equation (6) is adjusted to the smallest integer Q , denoted by Q_U^* , that satisfies

$$(r - s + nh)F_n(Q) \geq r - c. \quad (8)$$

When the entire demand is concentrated in the last epoch, $F_k(Q) = 1$ for $k = 1, 2, \dots, n-1$, and the optimality condition in Equation (6) is adjusted to the smallest integer Q , denoted by Q_L^* , that satisfies

$$(r - s + h)F_n(Q) + (n-1)h \geq r - c. \quad (9)$$

Comparing Equation (8), (9) and (6) yields

Theorem 3. $Q_L^* \leq Q^* \leq Q_U^*$.

Using algebraic manipulations, Equation (8) can be written as the smallest integer Q that satisfies $F_n(Q) \geq c_u / (c_o + c_u)$. Thus, Q_U^* is the solution of the classical newsvendor problem with underage and overage costs of the exact optimality condition in Equation (7). Actually, Q_U^* is the solution of the classical newsvendor problem where the holding costs of units sold within the selling period are neglected, but the holding cost of units that are left over at the end of the period are considered (Nahmias [16], p. 284).

Similarly, using algebraic manipulations, Equation (9) can be written as the smallest integer Q that satisfies $F_n(Q) \geq c_u^L / (c_o + c_u^L)$, where $c_u^L = r - c - (n-1)h$. Thus, Q_L^* is the solution of the classical newsvendor problem with an exact overage cost and a reduced underage cost. The adjustment of the underage cost reflects a case in which all units are held in inventory for $n-1$ epochs, until demand occurs in the last epoch, so that the unit purchase cost actually includes an additional component, $(n-1)h$, which is the fixed holding cost in this scenario before the sale begins.

4.2. Approximations of Q^*

A naïve heuristic to approximate Q^* is using the floor function (*i.e.*, the largest integer from below) on the average of the bounds, $Q_A^* = 0.5 \lfloor Q_L^* + Q_U^* \rfloor$. It is clear that relative to other values of $Q \in (Q_L^*, Q_U^*)$, Q_A^* minimizes the worst deviation from Q^* . However, the actual performance of Q_A^* should be further investigated (see Subsection 5.1).

We continue with more sophisticated approximations, which are based on additional information on the demand process. Although it is difficult to find a closed-form expression of the inverse CDF of X (*i.e.*, its quantile function), it is easy to find the expectation and variance of X . By the properties of mixtures (Chatfield and Theobald [15]):

$$E[X] = \sum_{k=1}^n w_k \mu_k \quad (10)$$

$$V[X] = \sum_{k=1}^n w_k (\sigma_k^2 + \mu_k^2) - E^2[X]. \quad (11)$$

Thus, the inverse CDF of X can be approximated by the inverse CDF of another distribution with the same expectation and variance (*i.e.*, a two-moment approximation), which has a closed-form expression. Rudi *et al.* [1] suggest using the normal distribution, and Gallego [19] suggests both the normal and the log-normal distributions according to the coefficient of variation of X .

Accordingly, after substituting c_u and c_o and rounding the result to the closest integer, the optimal order quantity obtained with the two-moment normal approximation is:

$$Q_N^* = \left\lceil 0.5 + E[X] + \sqrt{V[X]} \Phi^{-1} \left(\frac{r - c}{r - s + nh} \right) \right\rceil, \quad (12)$$

and the quantity obtained with the two-moment lognormal approximation is:

$$Q_{LN}^* = \left\lceil 0.5 + \exp \left[\ln(E[X]) - 0.5 \ln \left(1 + \frac{V[X]}{E^2[X]} \right) + \sqrt{\ln \left(1 + \frac{V[X]}{E^2[X]} \right)} \Phi^{-1} \left(\frac{r - c}{r - s + nh} \right) \right] \right\rceil, \quad (13)$$

where Φ^{-1} is the standard normal inverse CDF function. Although these approximations use additional infor-

mation on the demand process, their accuracy levels depend on the extent to which the exact distribution of mixture X is close to the normal or lognormal distributions, respectively (see Subsection 5.1).

4.3. Practical Merit and Limitations of the Heuristic Solutions

In some cases, the distribution of the demand in each epoch is known, but it is difficult to analytically calculate the distribution of the cumulative demand over the first k epochs (*i.e.*, $F_k(\cdot)$). This might occur, for example, when demand in each epoch is uniformly distributed or when epochs' demands are mutually dependent. In such cases, the CDFs $F_k(\cdot)$, $k = 1, 2, \dots, n$, can be estimated by various statistical methods (e.g., Monte-Carlo simulation). Alternatively, the two-moment approximations can be used, as they require only the expectation and variance of D_k . When epochs' demands are independent $E[D_k] = \sum_{k=1}^n E[d_k]$ and $V[D_k] = \sum_{k=1}^n V[d_k]$. These approximations are also useful in cases where information regarding the expectation and variance of demand is gathered over time, but not the exact distribution. Unfortunately, these approximations have no useful bounds on their potential deviations from the optimal order quantity and from the maximal expected profit.

Another case in which heuristic solutions are useful is when only partial information on the demand process across the epochs is available, e.g., when we know the demand distribution over the entire selling period (as is common in the newsvendor problem), but not the distribution in each epoch. In such cases, Q_L^* and Q_U^* can be used to estimate the value of full information on the demand process, as described in Theorem 4. Clearly, the uncertainty regarding the optimal order quantity is limited to $\delta \equiv Q_U^* - Q_L^*$. Consequently, the uncertainty regarding the maximal profit can be limited according to:

Theorem 4. $\pi(Q^*) - \pi(Q) \leq \Lambda \equiv (Q_U^* - Q_L^*) \max\{c - s + nh, r - c\}$ for $Q \in [Q_L^*, Q_U^*]$.

Proof. Since $Q^* \in [Q_L^*, Q_U^*]$, then $\pi(Q^*) - \pi(Q) \leq (Q_U^* - Q_L^*) \max|\Delta\pi(Q)|$ for $Q^* \in [Q_L^*, Q_U^*]$. The theorem is proved since, by Equation (5), $-(c - s + nh) \leq \Delta\pi(Q) \leq r - c$ (implied from the restriction $0 \leq F_k(Q) \leq 1$, $k = 1, 2, \dots, n$).

The practical merit of Theorem 4 is that when the value of Λ is smaller than a predetermined threshold, then we know ahead that using a search procedure to find Q^* is not economically justified.

5. Results under a Non-stationary Poisson Demand Process

Numerous models in the inventory literature assume, justifiably, that demand is characterized by a Poisson distribution (Nahmias [16], p. 287). However, the assumption of a stationary Poisson process (e.g., [2], p. 45) may not suit the cases of perishable items (e.g., [5]–[8]) or deteriorating items (e.g., [9] [20] [21]). Therefore, we continue with an example that follows a non-stationary Poisson process, where $d_j \sim \text{Poisson}(\lambda_j)$ (independently of d_i , $i \neq j$), so that $D_k \sim \text{Poisson}(\mu_k = \sum_{j=1}^k \lambda_j)$. Applying Equation (10) in Appendix 3 of Hadley and Whitin [11] in Equation (6), the expected shortage in Equation (4) for the Poisson process can be simplified to

$$\eta_k(Q) = \mu_k(1 - F_k(Q - 2)) - Q(1 - F_k(Q - 1)). \quad (14)$$

In our numerical examples in the following subsection, it is assumed that

$$\lambda_k = \begin{cases} \lambda_1 \cdot \left(\frac{N - k + 1}{N}\right)^\beta, & 1 \leq k \leq N \\ 0, & k \geq N + 1 \end{cases} \quad (15)$$

where λ_1 is the expected demand for a fresh item per epoch; N is an item's shelf-life duration, measured in number of epochs; and β is the demand deterioration coefficient across epochs. According to Avinadav and Arponen [5], this polynomial form is general enough to represent various decreasing behaviors of λ_k : $\beta = 0$ reflects no decrease; $0 < \beta < 1$ reflects a moderate decrease (concave function); $\beta = 1$ reflects a constant decrease (linear function); and $\beta > 1$ reflects a rapid decrease (convex function).

5.1. Experiment Design and Results

In order to evaluate the performance of the three heuristic solutions and of the two bounds in the previous sec-

tion, we use 64 numerical examples in a two- and four-level factorial design of the model parameters. In all the examples we assume that 1) an epoch is a day; 2) a unit costs the vendor $c = 1$ dollar; 3) a unit's shelf-life duration is $N = 10$ days; and 4) the expected demand for a fresh item is $\lambda_1 = 20$ units per day. To create different scenarios, we use two or four levels of values for each parameter. We use two values for h (0.1 and 0.2 dollars per unit per day), n (5 and 10 days) and s (0.5 and 0 dollars per unit). Since the values of n and s might be correlated (the salvage value usually decreases as the selling period approaches the shelf-life duration), we use the high value of n with the low value of s and vice versa. We use four values for r (2, 2.5, 3 and 3.5 dollars per unit), as well as for β (0, 0.5, 1 and 2 for zero, moderate, constant and rapid decreasing behaviors of λ_k , respectively).

For each of the 64 combinations of the parameter values we calculate Q^* (by Equation (6)), Q_U^* (by Equation (8)), Q_L^* (by Equation (9)), $Q_A^* = 0.5[Q_L^* + Q_U^*]$, Q_N^* (by Equation (10)) and Q_{LN}^* (by Equation (11)). Since $\sigma_k^2 = \mu_k$ in the Poisson distribution, Q_N^* and Q_{LN}^* are calculated by

$$E[X] = \sum_{k=1}^n w_k \mu_k = \frac{1}{r-s+nh} \left(h \sum_{k=1}^{n-1} \mu_k + (r-s+h) \mu_n \right) \quad (16)$$

and

$$V[X] = \sum_{k=1}^n w_k (\mu_k + \mu_k^2) - E^2[X] = E[X] - E^2[X] + \frac{1}{r-s+nh} \left(h \sum_{k=1}^{n-1} \mu_k^2 + (r-s+h) \mu_n^2 \right) \quad (17)$$

For each of the five values of Q we calculate the expected profit by Equation (4) and Equation (14), and Λ by Theorem 4. The results are presented in **Table 1**.

In order to evaluate the performance of the heuristics and of the bounds, we calculate for each one the absolute values of the percentage deviation from the optimal order quantity and the resultant percentage deviation from the maximal profit. The results, ordered according to size of deviation, are presented in **Figure 2-5** provide a zoom in **Figure 2** and **Figure 3**, respectively, after screening eight instances in which the lower bound failed to provide valuable information.

5.2. Analysis of Results

The lower bound, Q_L^* , produced the largest maximal percentage deviations from Q^* (100%) and from $\pi(Q^*)$

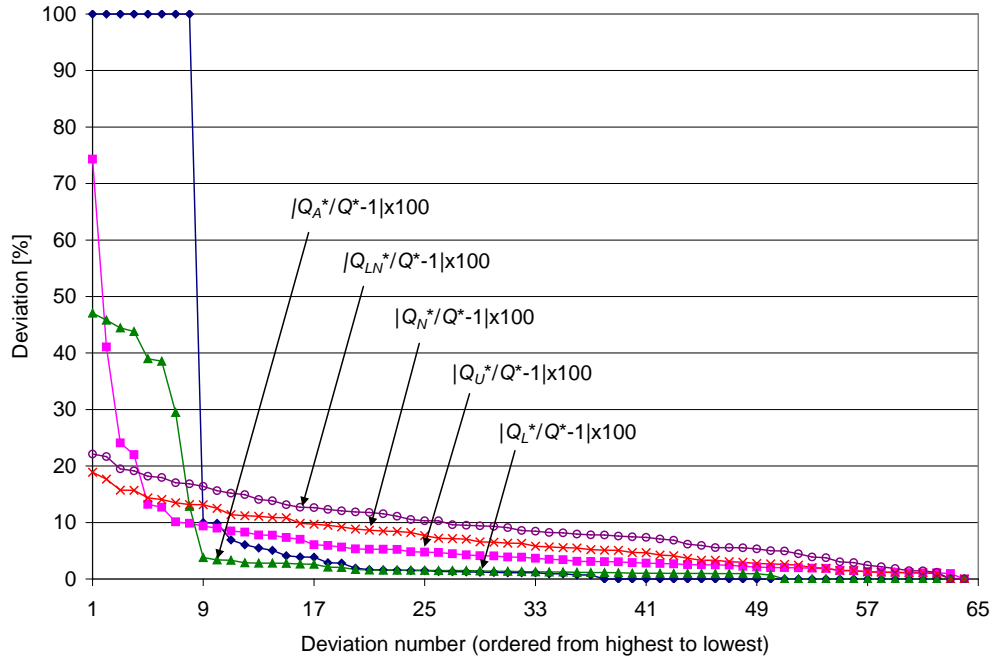


Figure 2. Percentage deviations (in absolute value) of Q_L^* , Q_U^* , Q_A^* , Q_N^* and Q_{LN}^* from Q^* , sorted in descending order by size.

Table 1. Results of the 64 factorial experiments.

Parameters							Order quantities [units]						Expected profits [\$]						Gap [\$]
no.	n	s	r	h	β	Q^*	Q_L^*	Q_U^*	Q_A^*	Q_N^*	Q_{LN}^*	$\pi(Q^*)$	$\pi(Q_L^*)$	$\pi(Q_U^*)$	$\pi(Q_A^*)$	$\pi(Q_N^*)$	$\pi(Q_{LN}^*)$	Λ	
1	5	0.5	2	0.1	0	97	97	100	98	90	87	74.0	74.0	73.6	73.9	72.7	71.4	3.0	
2	5	0.5	2	0.1	0.5	86	86	89	87	81	78	66.7	66.7	66.4	66.6	65.9	64.7	3.0	
3	5	0.5	2	0.1	1	77	77	80	78	73	71	60.6	60.6	60.3	60.5	60.0	59.3	3.0	
4	5	0.5	2	0.1	2	64	63	66	64	61	59	51.0	51.0	50.7	51.0	50.7	50.1	3.0	
5	5	0.5	2	0.2	0	89	88	97	92	77	73	56.6	56.5	54.9	56.3	54.3	52.9	13.5	
6	5	0.5	2	0.2	0.5	79	78	87	82	70	67	52.3	52.3	50.5	52.1	50.7	49.7	13.5	
7	5	0.5	2	0.2	1	71	69	78	73	64	61	48.6	48.5	47.0	48.5	47.4	46.4	13.5	
8	5	0.5	2	0.2	2	59	56	64	60	54	52	42.5	42.3	41.4	42.5	41.8	41.2	12.0	
9	5	0.5	2.5	0.1	0	100	100	102	101	98	95	121.6	121.6	121.5	121.6	121.4	120.4	3.0	
10	5	0.5	2.5	0.1	0.5	90	89	91	90	87	85	109.0	109.0	108.9	109.0	108.7	108.1	3.0	
11	5	0.5	2.5	0.1	1	80	80	82	81	79	77	98.5	98.5	98.4	98.5	98.4	97.9	3.0	
12	5	0.5	2.5	0.1	2	66	66	68	67	65	64	82.1	82.1	82.0	82.1	82.0	81.8	3.0	
13	5	0.5	2.5	0.2	0	95	95	100	97	87	83	102.2	102.2	101.2	102.1	99.8	97.3	7.5	
14	5	0.5	2.5	0.2	0.5	85	84	89	86	78	75	92.8	92.8	92.0	92.7	91.0	89.3	7.5	
15	5	0.5	2.5	0.2	1	76	76	80	78	71	68	84.9	84.9	84.1	84.7	83.8	82.2	6.0	
16	5	0.5	2.5	0.2	2	63	62	66	64	59	57	72.3	72.3	71.7	72.3	71.6	70.7	6.0	
17	5	0.5	3	0.1	0	103	103	104	103	102	100	170.0	170.0	170.0	170.0	170.0	169.6	2.0	
18	5	0.5	3	0.1	0.5	92	92	93	92	91	90	152.1	152.1	152.0	152.1	152.0	151.9	2.0	
19	5	0.5	3	0.1	1	83	82	84	83	82	81	137.0	137.0	136.9	137.0	137.0	136.9	4.0	
20	5	0.5	3	0.1	2	68	68	69	68	68	67	113.8	113.8	113.8	113.8	113.8	113.7	2.0	
21	5	0.5	3	0.2	0	98	98	102	100	93	90	149.3	149.3	148.7	149.2	147.8	145.7	8.0	
22	5	0.5	3	0.2	0.5	88	88	91	89	83	81	134.7	134.7	134.1	134.6	133.5	132.2	6.0	
23	5	0.5	3	0.2	1	79	79	81	80	75	73	122.4	122.4	122.1	122.3	121.6	120.4	4.0	
24	5	0.5	3	0.2	2	65	65	67	66	63	61	103.2	103.2	102.9	103.1	102.9	102.0	4.0	
25	5	0.5	3.5	0.1	0	104	104	106	105	106	104	218.8	218.8	218.7	218.8	218.7	218.8	5.0	
26	5	0.5	3.5	0.1	0.5	93	93	94	93	94	93	195.4	195.4	195.4	195.4	195.4	195.4	2.5	
27	5	0.5	3.5	0.1	1	84	84	85	84	85	83	176.0	176.0	175.9	176.0	175.9	175.9	2.5	
28	5	0.5	3.5	0.1	2	70	70	70	70	70	69	145.9	145.9	145.9	145.9	145.9	145.8	0.0	
29	5	0.5	3.5	0.2	0	101	101	103	102	98	95	197.3	197.3	196.9	197.1	196.8	195.2	5.0	
30	5	0.5	3.5	0.2	0.5	90	90	92	91	87	85	177.3	177.3	176.9	177.2	176.8	175.8	5.0	
31	5	0.5	3.5	0.2	1	81	81	83	82	79	77	160.6	160.6	160.2	160.4	160.4	159.6	5.0	
32	5	0.5	3.5	0.2	2	67	66	68	67	66	64	134.5	134.5	134.4	134.5	134.5	133.9	5.0	
33	10	0	2	0.1	0	180	177	194	185	146	141	106.5	106.4	102.8	106.0	99.5	97.8	34.0	
34	10	0	2	0.1	0.5	128	123	137	130	110	107	86.0	85.6	83.7	85.9	81.8	80.6	28.0	
35	10	0	2	0.1	1	99	93	105	99	88	86	72.2	71.2	70.9	72.2	69.4	68.5	24.0	
36	10	0	2	0.1	2	70	63	73	68	65	64	55.0	53.3	54.4	54.9	54.1	53.8	20.0	
37	10	0	2	0.2	0	109	0	190	95	113	111	59.6	0.0	23.3	58.6	59.6	59.6	570.0	
38	10	0	2	0.2	0.5	95	0	134	67	89	88	55.1	0.0	39.5	49.7	54.8	54.7	402.0	
39	10	0	2	0.2	1	83	0	103	51	74	73	51.2	0.0	43.4	41.9	50.3	50.1	309.0	
40	10	0	2	0.2	2	63	0	71	35	57	56	44.0	0.0	41.3	31.6	43.1	42.8	213.0	
41	10	0	2.5	0.1	0	190	190	197	193	165	158	198.7	198.7	197.1	198.4	187.1	181.9	14.0	

Continued

42	10	0	2.5	0.1	0.5	134	133	140	136	121	117	151.2	151.1	149.9	151.1	145.6	142.6	14.0
43	10	0	2.5	0.1	1	104	102	108	105	96	94	122.4	122.2	121.6	122.4	119.7	118.3	12.0
44	10	0	2.5	0.1	2	73	70	75	72	70	68	90.0	89.5	89.7	90.0	89.5	88.6	10.0
45	10	0	2.5	0.2	0	159	0	194	97	134	128	126.9	0.0	113.2	107.3	123.6	121.9	582.0
46	10	0	2.5	0.2	0.5	121	0	137	68	102	99	110.2	0.0	102.8	84.1	105.8	104.5	411.0
47	10	0	2.5	0.2	1	96	0	105	52	84	81	96.4	0.0	92.6	68.4	93.2	91.6	315.0
48	10	0	2.5	0.2	2	68	0	73	36	62	61	76.7	0.0	75.1	50.3	74.9	74.4	219.0
49	10	0	3	0.1	0	195	195	200	197	177	171	293.7	293.7	292.5	293.4	283.1	276.6	10.0
50	10	0	3	0.1	0.5	138	138	142	140	129	125	218.2	218.2	217.4	218.0	214.2	210.5	8.0
51	10	0	3	0.1	1	107	106	110	108	102	99	174.1	174.0	173.5	174.0	172.6	170.4	8.0
52	10	0	3	0.1	2	75	74	77	75	73	71	125.9	125.8	125.6	125.9	125.6	124.7	6.0
53	10	0	3	0.2	0	181	179	196	187	149	141	213.4	213.3	206.7	212.6	200.8	195.7	51.0
54	10	0	3	0.2	0.5	129	124	139	131	112	107	172.8	171.8	168.3	172.7	165.0	161.1	45.0
55	10	0	3	0.2	1	101	94	107	100	90	87	145.2	143.2	142.6	145.2	140.5	138.0	39.0
56	10	0	3	0.2	2	71	64	75	69	66	65	111.0	107.8	109.6	110.8	109.3	108.6	33.0
57	10	0	3.5	0.1	0	198	198	202	200	187	180	389.9	389.9	389.0	389.7	384.1	375.8	10.0
58	10	0	3.5	0.1	0.5	141	140	144	142	135	131	286.1	286.1	285.4	286.0	284.2	280.7	10.0
59	10	0	3.5	0.1	1	109	108	111	109	106	103	226.4	226.4	226.2	226.4	225.8	223.8	7.5
60	10	0	3.5	0.1	2	77	76	78	77	75	74	162.4	162.4	162.2	162.4	162.1	161.8	5.0
61	10	0	3.5	0.2	0	188	188	198	193	161	152	305.5	305.5	301.1	304.5	287.8	278.6	30.0
62	10	0	3.5	0.2	0.5	134	132	141	136	119	114	237.9	237.8	234.5	237.6	229.0	223.4	27.0
63	10	0	3.5	0.2	1	104	101	109	105	95	92	195.6	195.1	193.3	195.4	191.1	187.9	24.0
64	10	0	3.5	0.2	2	73	69	76	72	69	67	146.3	144.9	145.3	146.2	144.9	143.2	21.0

(100%). However, further analysis shows that such extreme deviations occurred only when Q_L^* was equal to zero (*i.e.*, the bound failed to provide valuable information). On the other hand, when Q_L^* was positive (in 56 out of the 64 instances), its associated percentage deviations were generally lower than those produced by using the other heuristics (see [Figure 4](#) and [Figure 5](#)), with up to 10% deviation from Q^* (1.5% on average) and up to 3% deviation from $\pi(Q^*)$ (0.2% on average). We analyzed the eight instances in which Q_L^* was ineffective (no. 37 - 40 and 45 - 48 in [Table 1](#)), and found that they were characterized by high levels of n and h , low levels of s and relatively low levels of r . The relation between these characteristics and a Q_L^* value of zero can be explained by low profitability of the item (implying low c_u^L) when all sold units are associated with substantial holding costs over the selling period, regardless of their exact duration in inventory.

The higher bound, Q_U^* , produced large maximal percentage deviations from Q^* (74.3%) and from $\pi(Q^*)$ (60.9%). If we disregard the eight problematic instances (no. 37 - 40 and 45 - 48), then the maximal percentage deviations produced by using Q_U^* are similar to those produced by using Q_L^* (10.1% from Q^* and 3.5% from $\pi(Q^*)$). On the other hand, the average percentage deviations produced by using Q_U^* (3.8% from Q^* and 0.9% from $\pi(Q^*)$) are considerably larger than those produced by using Q_L^* .

The average of the bounds, Q_A^* , produced maximal and average deviations from Q^* (47.1% and 5.8%, respectively) and from $\pi(Q^*)$ (34.4% and 2.6%, respectively) that were lower than those obtained by using Q_L^* or Q_U^* . If we disregard the eight problematic instances (no. 37 - 40 and 45 - 48), then Q_A^* produced excellent maximal and average deviations from Q^* (3.8% and 1.2%, respectively) and from $\pi(Q^*)$ (0.4% and 0.1%, respectively).

The two-moment lognormal approximation always produced a lower optimal order quantity than did the two-moment normal approximation (*i.e.*, $Q_{LN}^* < Q_N^*$). Notably, however, in most cases, using the two-moment normal approximation produced a lower-than-optimal order quantity ($Q_N^* < Q^*$ in 60 out of the 64 instances), which explains why, in most cases, using Q_{LN}^* led to a higher percentage deviation from $\pi(Q^*)$ than did us-

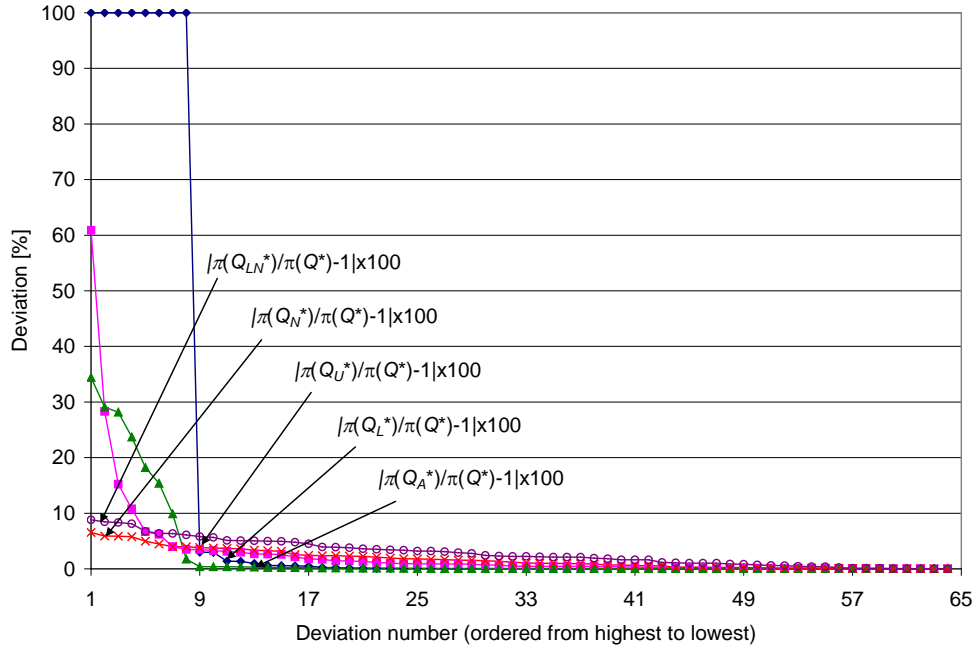


Figure 3. Percentage deviations (in absolute value) of $\pi(Q_L^*)$, $\pi(Q_U^*)$, $\pi(Q_A^*)$, $\pi(Q_N^*)$ and $\pi(Q_{LN}^*)$ from $\pi(Q^*)$, sorted in descending order by size.

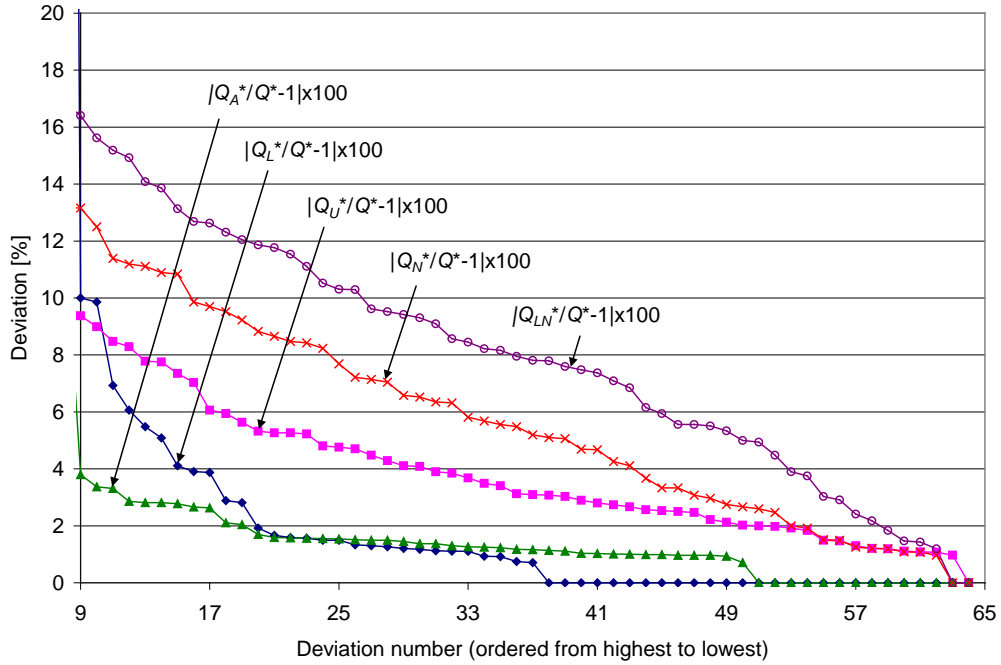


Figure 4. Percentage deviations (in absolute value) of Q_L^* , Q_U^* , Q_A^* , Q_N^* and Q_{LN}^* from Q^* , sorted in descending order by size (without instances no. 37 - 40 and 45 - 48 in Table 1).

ing Q_N^* . By Figure 2 and Figure 3, we see that, in comparison to Q_L^* and Q_U^* , Q_N^* and Q_{LN}^* produced lower maximal percentage deviations from Q^* (18.9% and 22.1%, respectively) and from $\pi(Q^*)$ (6.6% and 8.8%, respectively). However, if we disregard the eight instances with a Q_L^* value of zero, then using Q_N^* and Q_{LN}^* produced average percentage deviations from Q^* (6.3% and 8.9%, respectively) and from $\pi(Q^*)$ (1.7%

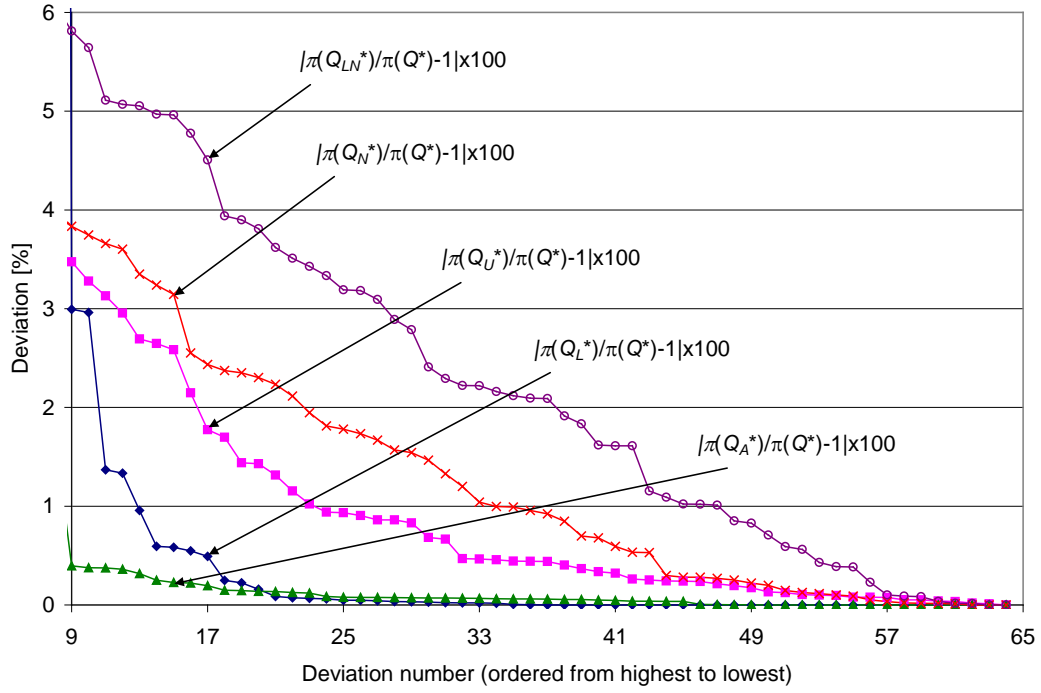


Figure 5. Percentage deviations (in absolute value) of $\pi(Q_L^*)$, $\pi(Q_U^*)$, $\pi(Q_A^*)$, $\pi(Q_N^*)$ and $\pi(Q_{LN}^*)$ from $\pi(Q^*)$, sorted in descending order by size (without instances no. 37 - 40 and 45 - 48 in Table 1).

and 2.9%, respectively) that were considerably higher than those produced by using Q_L^* and Q_U^* (see above).

We investigate now why the values of Q_N^* and Q_{LN}^* tended to be lower than the optimal order quantity. To do so, we analyze instance no. 33 in Table 1 ($n = 10$, $s = 0$, $r = 2$, $h = 0.1$ and $\beta = 0$). By Equation (15), $\lambda_k = 20$, so that for the Poisson process $\mu_k = \sigma_k^2 = 20k$ and $F_k(j) = e^{-20k} \sum_{i=0}^j (20k)^i / i!$ for $k = 1, 2, \dots, 10$. By Section 3, $w_k = 0.0333$ for $k = 1, 2, \dots, 9$, and $w_{10} = 0.7$, so that, by Equation (7),

$$F_{\text{mixture}}(j) \equiv F_X(j) = 0.0333 \sum_{k=1}^9 F_k(j) + 0.7 F_{10}(j), \quad (18)$$

by Equation (10), $E[X] = 170$, and by Equation (11), $V[X] = 3070$. Thus, the two-moment normal approximation of the CDF of X is

$$F_{\text{normal}}(j) = \Phi((j - 170) / 55.4076), \quad (19)$$

and the two-moment lognormal approximation of the CDF of X is

$$F_{\text{lognormal}}(j) = \Phi(\ln(j) - 5.08532 / 0.31774). \quad (20)$$

By the ratio from the right-hand side of Equation (7), $(r - c) / (r - s + nh) = 0.333$.

The three CDFs, $F_{\text{mixture}}(j)$, $F_{\text{normal}}(j)$ and $F_{\text{lognormal}}(j)$, are plotted in Figure 6, from which it is clear that $F_{\text{lognormal}}^{-1}(\varphi) < F_{\text{normal}}^{-1}(\varphi) < F_{\text{mixture}}^{-1}(\varphi)$ for $\varphi \in (0.2, 0.7)$. We therefore conclude that the reasons why the values of Q_N^* and Q_{LN}^* were lower than those of Q^* in most of our 64 instances were that: 1) the values of the ratio $(r - c) / (r - s + nh)$ were from 0.25 to 0.714, and 2) the order of the three inverse CDFs, $F_{\text{lognormal}}^{-1}(\varphi)$, $F_{\text{normal}}^{-1}(\varphi)$ and $F_{\text{mixture}}^{-1}(\varphi)$ for $\varphi \in (0.2, 0.7)$, mostly remained as plotted in Figure 6.

To summarize this section, we highlight the following results. First, the distributions of the percentage deviations from Q^* and from $\pi(Q^*)$ were mostly preferable for the lower bound, Q_L^* , than for the upper bound, Q_U^* , except in cases with a Q_L^* value of zero. Second, the percentage deviations (maximal and average) obtained with Q_A^* (the average of the upper and lower bounds) were mostly better than those obtained with each bound separately. Finally, although the two-moment approximations, Q_N^* and Q_{LN}^* , used more information on

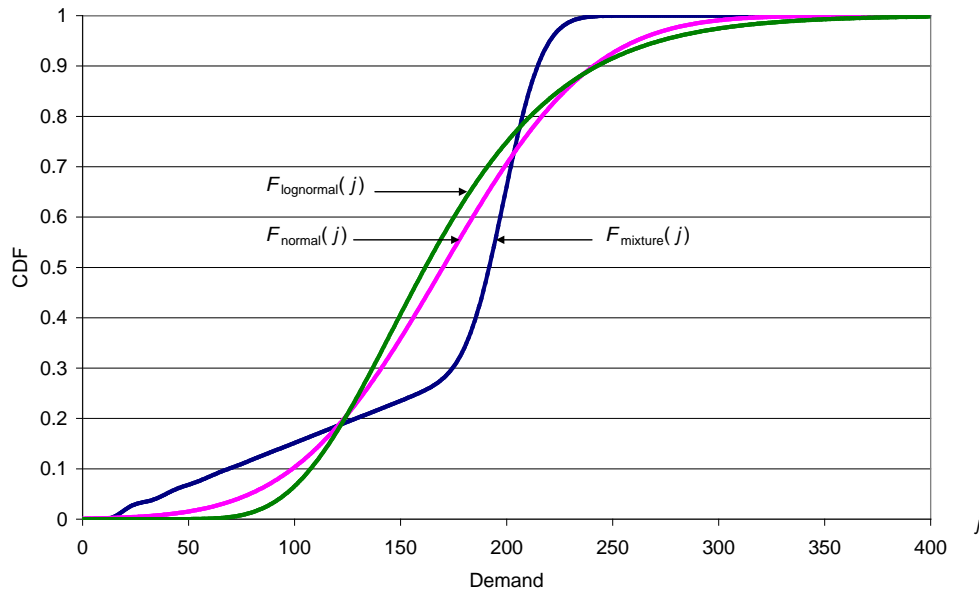


Figure 6. Plot of $F_{\text{mixture}}(j)$, $F_{\text{normal}}(j)$ and $F_{\text{lognormal}}(j)$ for $n = 10$, $d = 0$, $r = 2$, $h = 0.1$, $s = 0.5$ and $\beta = 0$.

the demand process (the expectation and variance of the demand in each epoch) than did Q_L^* and Q_U^* (which only required knowing the demand distribution over the entire period), they produced less-preferable distributions of percentage deviations from Q^* and from $\pi(Q^*)$. These two-moment approximations performed better than the upper and lower bounds mostly in cases with a Q_L^* value of zero. This surprising result can be explained by the exact distribution of the mixture, X , which is quite different from the normal or the lognormal distributions. For this reason, the two-moment approximations were associated, in most cases, with negative deviation from Q^* .

6. Managerial Implications

Our accounting approach for inventory costs is primarily applicable to food and fashion products, for which the most suitable periodic inventory models are newsvendor problems with non-short selling period durations, such that holding costs of sold units cannot be neglected as in the classical model. Practitioners who manage numerous products under frequent cost updates (e.g., in supermarkets) may find it difficult to repeatedly implement multiple search procedures for extracting the optimal order quantities. For such cases, we show that simple heuristics and bounds can be used. Specifically, we propose lower and upper bounds that are based on the classical newsvendor formula with modified cost parameters, and which can be implemented in a straightforward manner via an inventory support system or a spreadsheet. Given these bounds, we show how to identify instances in which the potential profit improvement that can be obtained by calculating the exact optimal order quantity does not economically justify the search for this order quantity. In such cases, we propose using the average of the upper and lower bounds as a more promising heuristic, and show that, indeed, this approximation yields considerably lower maximal and average percentage deviations compared with either the upper or the lower bounds. An attractive feature of the proposed heuristic is that it requires only the distribution of demand over the entire period, which is usually known in practice, and not full information on the demand process, which is more difficult to obtain.

For cases in which only partial information on the demand process is available—specifically, when the expectation and variance trajectories over the epochs are known, but the exact distribution of demand is unknown—we suggest two approximations, which are based on the classical newsvendor formula with normal and lognormal demand distributions. Using numerical examples, we find that these two-moment approximations produce lower maximal percentage deviations—but higher average percentage deviations—compared with the approximation based on the average of the upper and lower bounds. The two-moment approximations tended to

perform worse than the average of the bounds in cases where the lower bound was positive, and better when the lower bound was zero. Moreover, the normal approximation outperformed the lognormal approximation in most cases, and since it can be easily calculated using a spreadsheet, it is valuable for practitioners.

We hope that this work will convince researchers and especially practitioners that, in stochastic periodic-review inventory systems, it is beneficial to account for inventory costs exactly when they occur during the replenishment period. Though our analysis is based on the basic newsvendor model, we are convinced that similar benefits can be obtained for more elaborate inventory models. A promising direction for future research is implementing our accounting approach in multi-period models, as well as in models that include partial backlogging and spoilage, lead-time, fixed order cost and duration-dependent shortage cost. An additional direction for future work is improving the approximation formulas on the basis of the mixture's properties instead of relying on the normal or lognormal distributions arbitrarily.

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Appendix A

According to Appendix 5B in Nahmias [16], the expected profit in the classical newsvendor problem under continuous demand and without backlogging cost is

$$\pi(Q) = r \int_0^Q x f(x) dx + rQ \int_Q^\infty f(x) dx - h \int_0^Q (Q-x) f(x) dx - cQ,$$

where $f(x)$ is the probability density function (PDF) of the demand over the entire period, and h is the holding cost per unit of inventory remaining in stock at the end of the period.

Using the relation

$$\int_0^Q x f(x) dx = \mu - \int_Q^\infty x f(x) dx,$$

we obtain

$$\begin{aligned} \pi(Q) &= r \left(\mu - \int_Q^\infty x f(x) dx \right) + rQ(1 - F(Q)) - h \left(QF(Q) - \mu + \int_Q^\infty x f(x) dx \right) - cQ \\ &= (r+h)\mu + (r-c)Q - (r+h) \left(QF(Q) + \int_Q^\infty x f(x) dx \right) \\ &= (r+h)\mu + (r-c)Q - (r+h) \left(Q + \int_Q^\infty (x-Q) f(x) dx \right) \\ &= (r+h) \left(\mu - \int_Q^\infty (x-Q) f(x) dx \right) - (c+h)Q \end{aligned}$$

Substituting $n = 1$ and $s = 0$ in Equation (4) and defining $\mu \equiv \mu_n$ and $\eta(Q) \equiv \eta_n(Q)$ results in

$$\pi(Q) = r(\mu - \eta(Q)) - cQ - h(Q - \mu + \eta(Q)) = (r+h)(\mu - \eta(Q)) - (c+h)Q.$$

Thus, the classical newsvendor profit function is a special case of our generalized model.

On Service Productivity: The Emerging Platforms Perspective

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Abstract

Service research is yet looking for potentially effective methods to improve service industries. This study aims to develop a theoretical model for managing and improving service productivity from a macro industrial perspective (instead of a micro firm perspective). Through the meta analysis of surveying existing literature we develop hypotheses to construct a theoretical model for service productivity improvement. Four cases are used to explain, support and justify this proposed model. This model argues that three platform cornerstones of service productivity are to integrate participants (including consumers) to empower them (empowerment), making them adapt to one another (adaption) and sustain development (sustainability) to improve service productivity.

Keywords

Service Dominant Logic, Service Science, Platform, Empowerment, Adaption, Sustainability, Service Productivity

1. Introduction

One study pointed out that the service sector significantly affects a country's economic growth [1]. However, most researches focus on functional level rather than macro level which talked about how to improve the productivity of service industry sectors. Furthermore, as Bridges' opinion [2] pointed out, both entrepreneurship and innovation would be the important part of service research. Masso & Vahter's study [3] which found that the innovations would increase productivity in a service sector also supported Bridges' opinion. Although scholars recognized that the issue of productivity was important, there has not been a method that could be used to improve the innovations and productivity and describe the process of managing productivity improvement.

Hence, the aim of the study is to propose a theoretical concept, emerging platform, to be a basis of increasing service industries' productivity and construct a framework to describe the process. In this article, the emerging platform means a visible or non-visible platform which could carry the value creation entities, foster cooperations between these entities and drive the progress of productivity of a service system. In addition to the model to describe how an emerging platform works, some implications grounded on the proposed model will also be discussed in the last section.

Although scholars have applied the term of productivity which has been used in manufacturing, and modified its content for the service context [4], there has not been a consistent definition of service productivity among scholars so far. The definition of service productivity was discussed in Section 2. For solving the research question, this study takes two dimensions to address the research problem, which are service science and service dominant logic (SDL). This paper not only combines these two dimensions, but also adopts the value network perspective to propose a framework describing how the approach provided here improves service productivity in the long run. Based on the concept of a value network, the focus of this paper is no longer on a company or organization, but on a value-creating system [5]. Therefore, this paper discusses some characteristics of a value-creating system during the period of increasing service productivity through an approach for improving the service productivity of a service system.

For understanding the theoretical framework, this paper is organized as follows. The required foundational background is provided in Section 2. The theoretical framework is then proposed in Section 3. In Section 4, four cases are used to demonstrate and explain our theoretical framework, followed by its propositions developed and justified in Section 5. Finally, Section 6 provides the managerial implications and conclusion remarks.

2. Foundational Background

The proposed framework is based on some theoretical foundations, such as service dominant logic, service science, service systems and value networks. The contents of these theories are briefly described in this section. Besides briefing these theories, what service productivity means in this paper through a more systematic literature review is clearly identified.

2.1. Service Dominant Logic

Service dominant logic (SDL) was proposed by Vargo & Lusch [6] in 2004. It recognized some changes to Goods dominant logic in the world economies. Service and Goods dominant logics were a set of assumptions for the world in carrying out economic activities. There are three viewpoints proposed by service dominant logic that are the most significant [7]. First, they define a service as a process utilizing the firm's capability to benefit their customers. The competitive advantage is driven by the operant resources not the operand resources. Second, the value is co-created by providers and customers. This means customers would decide whether the service is valuable, and the firm only proposed the value proposition. Third, organizations play integrators to integrate resources to create value. According to the three viewpoints, SDL implied the interactions among firms (firms as integrator) and communications to customers (customer as co-creator) were important for service productivity.

2.2. Service Science and Service System

The term service science was proposed in 2004, and is denominated as Service Science, Management and Engineering (SSME) [8]. Hidaka [9] identified three main research issues in service science: 1) service innovation management, 2) technology to improve service productivity, 3) setting the price of services. This research is focused on the first two issues, which are searching for a systematic method to create service innovation and improving service productivity.

Service science adopts service system and system thinking as research perspectives to deal with its research issues. According to the definition of Spohrer *et al.* [10], a service system is a value co-production configuration of people, technology, other internal and external service systems, and shared information. The system thinking is a thinking framework based on service systems.

Vargo, Maglio & Akaka [11] also agreed a service system provides insight into value co-creation. The authors argue service systems interacting through service exchange relationships, an emphasized focal point in SDL, can improve the adaptability and survivability of all service systems that integrate resources in the interaction proc-

ess. Due to SDL contributions from an analytic perspective and service science as an identified research issue, the service system is an appropriate unit of analysis for service productivity and innovation. Researchers have shown the complementarities between SDL and the service system in terms of theory development [12] [13]. The service system is taken as a unit of analysis in this paper.

2.3. Service Productivity

This article aims to provide a way to higher the service productivity of a service systems or service industries. However, it is still hard to measure the service productivity. Hence, for a clear definition of “higher service productivity” we review relevant literature and synthesize them to construct indexes to measure the service productivity. These indexes were divided into two levels (micro and macro level) which were further explained below.

Productivity originally meant the ratio of output and input. It is a simple method and very suitable for manufacturing productivity. However, measuring service productivity is more complex. McLaughlin & Coffey [14] believed services have an inherent problem, intangibility, which causes some difficulties in measuring service productivity including quality, timing of demand and capacity. They also provided some strategies for measuring service productivity and especially emphasized that we cannot ignore the output/input ratio, even the output/input ratio is a traditional way to measure productivity. The output/input ratio signifies the level of efficiency. The other relevant concept is effectiveness, which is denoted as the ability of an organization to achieve its goal [15]. However, effectiveness has different meanings to firms and consumers. In the service era, consumers decide whether firms are effective. Firms tend to utilize resources as inputs for the transformation process, while customers evaluate the service process between service providers and customers [16]. It is obvious the concept of service productivity should consider service quality. McLaughlin & Coffey [17] and Filiatrault, Harvey & Chebat [18] also emphasized the role of service quality in service productivity management. Therefore, some scholars think service productivity and service quality should not be dealt with separately. So far, efficiency and effectiveness have been micro-level productivity (firm-level) concepts.

Besides micro-level productivity (efficiency, effectiveness or service quality), service productivity in this paper also covers service innovation, which is a macro-level productivity dimension. Maglio *et al.* [19] also referred to creating innovation through a service system. They took education, IT service delivery centers, call centers, and patents as examples to support the argument innovation could be improved through analyzing service systems. Innovation has been treated as an engine of economics, so service innovation as a dimension of service productivity should also be considered.

The other dimension of service productivity is the growth of industrial productivity. Based on traditional economic theory, an industry's total supply quantity is accumulated by each individual firm's quantity. Therefore, each individual firm's productivity increase implying an industrial productivity increase could also be inferred. On the other hand, more firms being created increases industrial service productivity, while industrial service innovation may create new business and attract new investment. Therefore, the literature is integrated to list the four dimensions of service productivity mentioned in this paper, which are efficiency, effectiveness, service innovation, and the growth of industrial service productivity. **Table 1** compares the productivity dimensions between service and manufacturing.

2.4. Value Networks

In the manufacturing age, traditional strategic analysis explains the firms' competitive behavior based on an assumption of the firm as an entity pursuing the maximization of profit or competitive advantage. The value chain was a useful tool at that time [20] [21]. However, in the service economy, the value chain is inappropriate for uncovering sources of value because the products and services became dematerialized [5] [22] [23].

In addition to the products and services being dematerialized, the “network economy” has been recognized as a new competitive reality in recent years [24]. Co-operative behavior is widely seen in an industry [25]. Inter-firm relationships are a more and more important focal analysis unit [26]. A group of firms cooperating to propose a value proposition used to be the major way to create value. When a value network perspective is adopted, the focus is not on firms or industries, but a value-creation system. Here, a value-creation system is a synonym for a service system. The service system is more widely applied to many kinds of objects, such as the service process, organization, collaboration among firms, and even the industrial or global ecosystem [27]. Each

Table 1. Comparison of the productivity issues between service and manufacturing.

Dimensions	Service productivity	Manufacturing productivity	Level of similarity
Efficiency	Mainly defined by input and output.	Mainly defined by input and output.	High
Effectiveness	Service firms consider not only the organizational purpose, but also the perception of customers.	Mainly refers to whether the manufacturing process achieves the organizational purpose.	Low
Innovation capability	Services are seen as a process, so service improvement involves other purposes beyond the organizational purpose. It always improves the customers' perceived value, quality, and reduces risk through a better service system.	To improve efficiency and effectiveness in terms of organizational purpose.	Low
Growth of industrial productivity	For services, it refers to increasing value creation capability through not only efficiency and effectiveness, but also innovation (it involves creating a new business model).	In manufacturing, it always refers to increasing value creation capability through efficiency and effectiveness improvement.	Low

service system could also be an entity in a higher-level service system, connected to one another by value propositions in a value-creating system [28].

Although the service system and value network are two sides of one coin, they provide different meanings for academic research. The system perspective provides concepts such as boundaries, elements, interactions, inputs, and outputs to use as the basis of service productivity. However, there is a lack of a methodological foundation for interaction analysis in the system perspective. Value network analysis can complement the drawbacks of the system perspective. Hence, in this research, the three important theoretical foundations are SDL, the service science and system, and the value network. The abovementioned theoretical perspectives are particularly treated in this study. Their relative relations are shown in **Figure 1**, which indicates that the value network perspective is adopted as a methodology to achieve the goal of increasing the service productivity of a service system under a SDL context.

3. The Theoretical Framework for Higher Service Productivity

This paper proposes a theoretical platform model featuring the important factors required in designing a better service system for higher service productivity.

3.1. The Proposed Platform Concept

A “platform” is a general term in many areas. Nowadays, the term is used to mean many objects in parallel positions interacting with each others to achieve a specific goal. Here, the term “platform” is borrowed to capture the reality of a physical or virtual space in which many entities are grounded, communicating and cooperating with one another to support the development of these entities, and continually changing through structural change and other outside environmental forces.

3.2. Theoretical Framework

In terms of the platform, there are three important factors that could be used to manage the platform for higher service productivity. They are empowerment, adaption, and sustainability. Empowerment enhances the ability of each entity through the service system in which they are located. Adaption leads to structural adjustment among entities for reacting to inside and outside forces. Finally, the platform can support an ecosystem to eliminate unqualified entities and attract new blood to achieve sustainability. There are also two important mediators, vitality and diversity, and relationships to connect factors as an integrated mechanism. The theoretical model is shown in **Figure 2** and will be described and justified afterwards.

As **Figure 2** shows, existing of the emerging platform could impact to some factors of a service system such as policy formation, information liquification, communication cost, transaction cost and others shows in **Figure 2**. Some of these factors would empower entities in a service system to do things more than what they can do before. Other factors would result in changes of value network. This phenomenon was called adaption in this article. In terms of emerging platform, empowerment and adaption were also the characteristics of the emerging platform. Furthermore, the empowerment and the adaption would lead a service system to sustainability, one of characteristics of emerging platform, through two mediators.

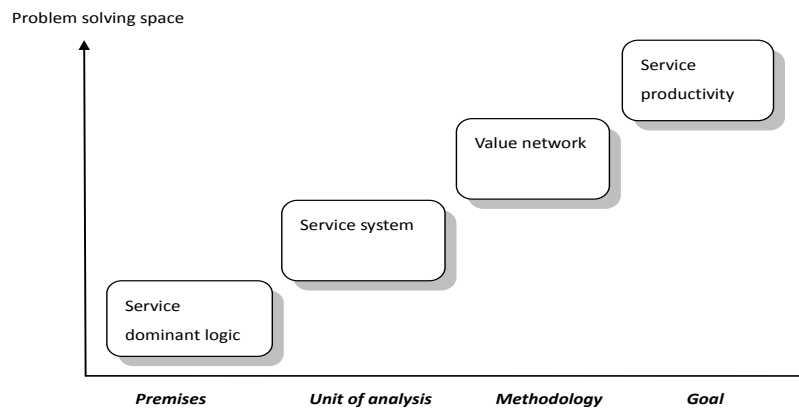


Figure 1. Integrating literature for service productivity.

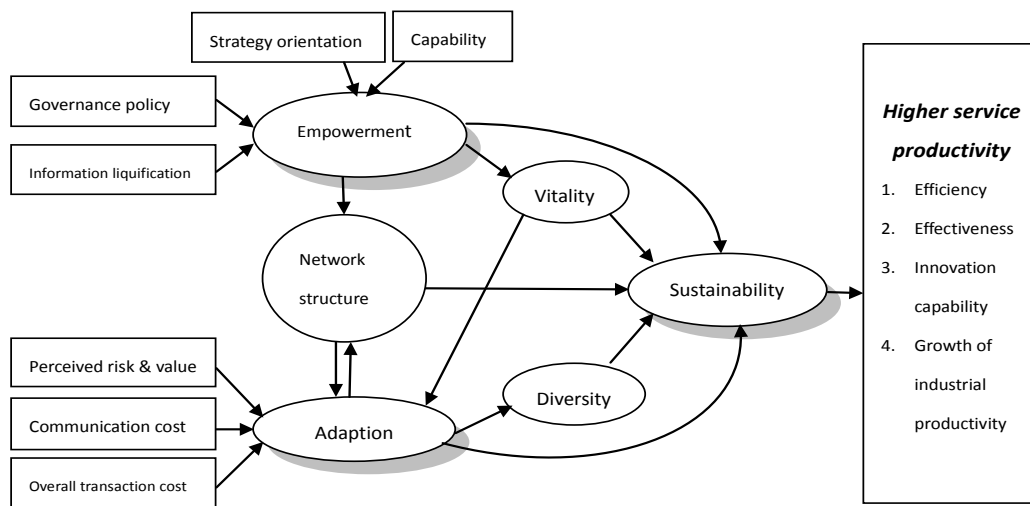


Figure 2. The theoretical model for higher service productivity through the service system platform.

Next section, we provided four mini cases (7-11, eBay, Hollywood and iTunes store) to support the validity of the theoretical model. Reasoning of relationships of factors shows in Figure 2 were provided after the discussions of four cases.

4. Four Cases for Understanding Service Productivity Improvement

Without loss of generalization, four existing platforms (7-11, eBay, Hollywood and iTunes) are examined to help understand our theoretical framework, of which the verifications are provided in Section 5. This section briefly describes how the cases demonstrate platform management for service productivity.

4.1. 7-11

7-11 is a convenient chain store founded in USA in 1946. In 1991, a Japanese firm, Ito Yokado, acquired more than half ownership of 7-11 from Southland Corporation, which is the founder company of 7-11. Now, it is the world's largest convenient chain store with owned stores in USA, Japan, Korea, Taiwan and other countries.

7-eleven Japan appears to be a platform creator or integrator. Their important philosophy is “co-existence” with their supplier and local community. 7-eleven Japan employs information systems throughout the entire chain. The information system connects more than 7000 stores and also controls the product distribution strategy. The information technology also contributes to service diversification to realize one of 7-eleven Japan's purposes, which is “self-reformation.” Now, 7-eleven Japan's business performance has exceeded its parent company (Ito-Yokado Co., Ltd.).

7-eleven Japan has also played a leadership role in the platform to co-develop new products with food manufacturers. The cooperation relationship built on the platform is based on mutual benefit. For example, manufacturers have an extensive sales force of 7000 chain stores and marketing information from these stores. 7-eleven Japan has increased their ability to develop new products and quickly develop more products at a given cost. Since 1980, 7-eleven Japan has continued to introduce services such as color copying, parcel home-delivery and so on to match their customers' needs. These new services help expand the customer base and bring "incidental shopping" to expand their business.

7-eleven Taiwan is a model using information technology to provide diversified services. "ibon" is a kind of information transformation machine and each 7-eleven store has one "ibon" in Taiwan. Customers could order tickets, clear parking bills, track delivered packages, and print documents or complete other services through a small machine. It is a model that creates value for stakeholders through co-creation (fewer employees needed for 7-11, more services are provided for customers, it is more efficient to complete the transaction for customers, 7-11, and third parties).

The case of 7-eleven Japan and Taiwan provide insights into increasing service productivity. Both 7-eleven Japan and Taiwan play lead roles as integrators of platforms. Through introducing IT technology into their services, they could improve the efficiency and effectiveness of their services. For example, "ibon" in 7-eleven makes several services easy enough to be performed by customers, so a 7-eleven store in Taiwan could perform more services than before with the existing employees and have very few service failures. On the other hand, 7-eleven closely connected their suppliers and benefitted one another by improving their innovation capabilities and reducing market risk. The suppliers could access market information through the powerful channel of 7-eleven. Since they could rapidly introduce new products onto the market, 7-eleven has also benefited from this advance. Today, 7-eleven services in Taiwan cover foods, daily commodities, books and magazines, online games, payment services, ordering tickets, logistics, and telecommunications. More services being completed and more innovation being created also meant a growth in industrial productivity. This demonstrates how stakeholders interact to improve service productivity and co-create wealth for stakeholders, including customers and the overall system.

4.2. eBay

eBay is a famous auction website founded in 1995 by Pierre Omidyar in the USA. At first, the website was named auction web, and then it was renamed eBay in 1997. More than 27,000 employees worked in eBay in 2011. Since 1995, the revenue of eBay has increased 17 times. Nowadays, there are more than 500,000 items sold through eBay in the world each day. Total transactions valued at more than 11 billion dollars occur on eBay's platform each year. It is also an international company operating in many countries including, Australia, Canada, German, Hong Kong, India, Taiwan, England, Spain, etc. In 2010, the market value of eBay exceeded 30 billion. Although eBay created a unique business model in its beginning, it also continued to acquire or ally itself with other service companies to upgrade its auction service (*i.e.* better service, user interface or experience). The sequence of acquisitions and alliances that formed eBay's value network included integrating e-Stamp, iShip, Mailbox Etc, iEscrow, Billpoint (Billpoint was closed when eBay acquired PayPal in 2002). These related services largely simplified users' transaction process and enhanced the security of the transaction. Along the path of eBay's growth, eBay also rapidly internationalized through foreign acquisition to expand their user base (including buyers and sellers).

In eBay's case, they integrated the operant resources such as third-party service companies, sellers, and buyers into their business value network. These operant resources interacted with one another under eBay's service design and management to create a positive loop in the service system. Rapidly entering foreign markets through acquisition or strategic alliances made their service content widespread, because more sellers meant more items were sold on eBay. More items being sold attracted more buyers due to the abundant choices, which in turn led to more sellers using their service.

On eBay's platform, sellers can access more potential buyers who they could not access before eBay's service was available. Buyers have more choices, which potentially satisfies their need and they could use digital computation to compare products and make the best choice. In this case, the platform empowered sellers and buyers to deal with one another more efficiently (decreasing transaction cost) and create huge transaction volume, which did not occur before eBay's platform was available. Because eBay attracted dealers, other service providers could easily see market opportunities. In sum, eBay created a platform that could facilitate interactions

among operant resources to increase service productivity from some dimensions such as efficiency, effectiveness, and industrial growth.

4.3. Hollywood

Hollywood has been a leader of the movie industry in the global market. Since 1911, the first movie studio was established in Hollywood. During the period of industry development, the industrial scale, structure and business model have largely changed. Industrial scale increased and the industrial structure shifted from vertical integration to networking cooperation. The business model became more diverse (movies were delivered through many channels, for example, DVD, TV or internet).

Even though Hollywood has experienced many changes, its competitive position is still sustained today. One of the reasons for Hollywood's success was a few main movie producers functioned as platforms to lead innovation and integrate the needed resources to propose value propositions. A critical incident in the history of Hollywood was the first animation (Snow White and the Seven Dwarfs) introduced by Disney in 1937. The animation was very successful, successfully opening up a new market (market innovation). The others movie producers were followers in this market. The first animation's success showed the old stories could generate revenue again. This is an example demonstrating the main movies producers could empower existing resources (traditional stories, market, technology), and adapt it to create a service system.

Pixar Animation was also an innovator in creating a new service system. They created a new market (children could also contribute to value creation, stories for children also generated new revenue), and a new venture firm focused on 3D animation also emerged. Related products were constantly introduced to the service system, for example, DVDs, original soundtracks, clothes with the movies on them, and others. In other words, a movie manufacturer adapted other firms to produce these related products to create a part of the value in the system. In sum, there are several main movie manufacturers in Hollywood, also called platforms in this article, acting as an integrator of human resources, scripts, and technologies. Today, even though the revenue from cinema is decreasing, the total production of Hollywood is still growing through the contribution of different channels [29].

4.4. iTunes Store

Recently, the music market has experienced a huge change due to Apple introducing the iPod and iTunes onto the digital music market in 2001. Obviously, these innovative services not only changed consumers' behavior in terms of listening to music and experiences, but also increased industrial growth by upgrading the value of music services. At the end of 2011, 16 billions songs had been downloaded from the iTunes store. The iTunes store had a 64% share of the American market of digital music in 2012. In addition to music, the iTunes store sequentially introduced new digital content categories, for example, books, movies, applications, and TV programs (only for few countries). In 2011, the revenue of the iTunes store reached 7 billion, which is a significant share of Apple's total revenue.

The start point of iTunes was offering an attractive device and a value proposition to their potential users. The value proposition is generated from the combination of product design, iTunes, and an image of a particular lifestyle. The iTunes store bridges the group of content providers to offer customers a deliberate product design. Actually, iTunes combines many operant resources to create this business system, including customers. These operant resources include the design skill, wireless technology, content providers' talent, management skills, users, techniques, and other advanced information technology.

In this case, Apple maintains a workable market (the service system corrected the imperfection of the real market) and a qualified interaction between two sides of content providers and users through deliberate management thinking, advanced information technology, and consumer experience. In the process of system formation, the platform empowers content providers to reach a group of potential customers and rapidly obtain feedback from users. The iPod users are also empowered in terms of their information search capability. Users can easily deal with any content provider, even if they did not know them before. The service system gradually changes through interactions among players, and the players who are new entrants or existing players continually adapt to the changing service system where they were. In the long run, the contents of the service system become more diverse in terms of its structure and attractiveness for potential users. In other words, the service system is dynamic and sustainable through its adaptability. In sum, the iTunes store is also a classic example of a positive loop system that continually grows (*i.e.* sustainability and service productivity).

5. Propositions Development

5.1. “Platform” as an Appropriate Theoretical Concept for Service Productivity

According to SDL, a service is defined as a firm using their capability to benefit others. Further, a service delivering a unique value proposition must be generated through the cooperation of many firms in terms of efficiency and effectiveness considerations, for example, mobile services. As Katz and Shapiro [30] said “many products have little or no value in isolation, but generate value when combined with others”. This statement also describes the nature of a service network. A single service provider may provide less value when it is isolated. Many studies also recognize the value network as an appropriate perspective to analyze the issues of value creation [5] [31]. However, scholars rarely focus on explaining how a value network actually emerges and how a value network grows as a system to achieve long-term sustainability.

From a capability perspective, a firm’s competitive advantage comes from its capability which other firms cannot imitate or substitute. This kind of capability is generated by a firm’s intangible resources [32] and routine activities [33]. Under the condition of limited resources and the goal of maximizing return, the firm focuses on a specific scope of value activities to generate superior value for target customers or other firms. A service must be completed through the cooperation of a group of firms (*i.e.* value network or service system). Networking is a fluid structure [34]. Such an organizational structure has an advantage in rapidly responding to the market and consumer taste change in the short term. 7-11, Hollywood, eBay and the iTunes store are good examples of adapting to the market. On the other hand, customers play an important role in value co-creation. Customers’ feedback helps firms assess their performance, and then identify performance gaps to improve [35]. To create a sustainable service system, customers should be a part of the service system.

Actually, from an SDL perspective, both customers and firms are a kind of operant resource. Given they are in a service system composed of complex interactions and relationships, the key issues are how the service system emerges and how to achieve and sustain higher service productivity. The four cases showed the emergence of a service system as a platform (hereafter called platform service system) which can facilitate interactions among resources. 7-11, eBay, iTunes, and Hollywood are platforms to support the interaction and integration of resources. Therefore, P1-1 is proposed.

P1-1: Based on a system thinking approach and SDL, identifying a platform that facilitates interactions among participants in a service value network is an effective approach to improve service productivity.

On a platform, firms and users gather to co-create value. It is argued a platform service system has three characteristics to perform its effective mechanism. These characteristics are empowerment, adaption, and sustainability. Examining the four cases, the first step in changing the status of a service system is to make the participants’ ability strong. For example, iTunes and eBay let their content providers access the potential market to decide what contents they should offer. On the other side, consumers are also empowered to influence firms’ behaviors and decisions, because the platform improves information distribution. Platform empowerment is defined as increasing the participants’ ability to make better decisions, and then acting to change their cooperation status (*i.e.* network structure in a service system).

The effect of adaption occurs if empowerment is effective. Hollywood is a good example of the effect of adaption. A movie is produced not only by several firms’ co-production, but also depends on the some new firms. For example, for 3D animations and movies introduced in recent years, new service firms specializing in 3D technology emerged soon after. Similar situations also occurred in other cases, such as with 7-11 or eBay. The participants continued adapting to the service system configured by all participants and this would lead to the sustainability of the service system.

P1-2: The platform improves service productivity through its characteristics of empowerment, adaption and sustainability.

5.2. To Empower All the Participants

Firms always seek market opportunities to make profits, but some lack the ability to do this, especially the small and medium sized enterprises (SMEs). However, there are two obstacles for firms, especially SMEs. First, SMEs might lack entrepreneurship. The second, as Shane [36] said “entrepreneurs could fail to identify opportunities or identify wrong opportunities”. Some theories of organizational behavior are helpful for firms that cannot act on valuable opportunities. Information gathering plays a key role in organizational behavior [37].

Pfeffer and Salancik [38] argued management itself could be considered as information gatherers. Of course, this includes the opportunity search process of an entrepreneur. The “platform” can be seen as an information hub helping participants in a service system to overcome information limitations. Hence, the platform enhances the firms’ capability through facilitating information flow to empower the individual firm to do something for value creation. The consumer side is also empowered by the platform. eBay is a typical case of consumer empowerment. Some evidence for empowerment is given in **Table 2**.

While the participants in a service system are empowered with more ability to adopt actions, the ecological system would also be changed by the actions of the participants based on the new perception generated from their broader vision (it is caused by empowerment).

P2-1: The characteristic of empowerment enables participants in a service value network to initiate network structure changes, and then adapt.

5.3. How a Platform Empowers Participants

P2-1 asserted empowerment would motivate network participants to initiate the changes of the system. Here, it is explained why and how empowerment pushes network participants to take actions to adopt the platform. As Chu [39] said, the software was more important than the hardware in a change process. Chu’s argument [39] implies changing behaviors are actually driven by the inner factor of an organization, although the hardware is well established. While a platform influence participants internally and externally, it makes participants change behaviors to act on what they need to do, and then the platform demonstrates the characteristic of empowerment. **Figure 3** shows a circle of empowerment. Any step could be an initial step of this circle, depending on what kinds of intervention occur in a service system. The next problem is what organizational factors affect their changed behaviors and result in the empowerment of a platform.

5.3.1. Internal Factors

Two factors that are altered by a platform, strategy orientation and capabilities, as well as empowering participants to take proactive action to make changes, are considered. Miles and Snow [40] proposed a strategy typology containing four kinds of strategy—defenders, prospectors, analyzers and reactors. Firms adopting prospector strategic orientation continually searched the new marketplace to become “creators of change” [41]. The platform, for example, 7-11, eBay and iTunes, offered a lot of market information to firms connected to the

Table 2. Evidence of a platform empowering participants.

Platform	Actions	Who are empowered	The results of empowerment
7-11	To take on a co-existence philosophy	Small service and product providers	To produce a platform
	To build an extensive sale force		Gaining small firms’ accessibility to the marketplace and market information
	To employ information technology	Customers	Customers increase their ability to deal with their daily life
	To add DIY services for customers		
eBay	To acquire or ally with other service companies	Small service providers	Small service companies could be connected to the information flow of the transaction
	Using IT technology to facilitate auction activities	Buyers	Buyers and sellers could efficiently and effectively find appropriate dealers
	Connecting sellers and buyers with one another	Sellers	
Hollywood	A few main producers bridge the market and small firms	Small service providers	Small service providers could connect to the demand side through the main producers
	A few main producers as integrators of a value network	New businesses emerge (ex, animation studios)	Incremental innovations are continually generated in Hollywood (ex, 3D movies and animation)
iTunes store	Collecting apps for iPhone and iPod users	Small service providers	Attracting more and more content providers
	Introducing others to existing content sequentially		Positive loop for content providers and users
	Creating a simple rule for transactions	Users	Contents are improved quickly
	Designing a mechanism for rapid feedback	Existing content	The large user base is an advantage for introducing other existing content (ex, TV program, open course, etc.)

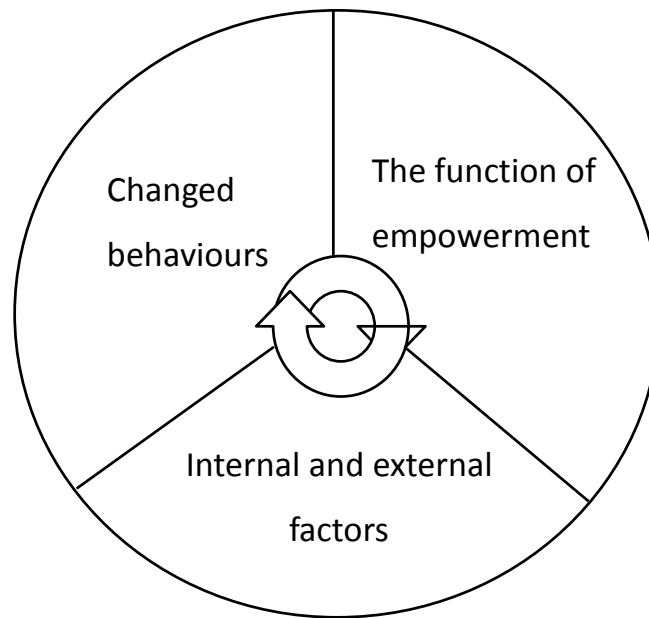


Figure 3. A general model for the function of empowerment.

platform. This information empowered the firms to innovate through taking a prospector strategic orientation. In the strategic research field, the capability means the ability of an organization to exploit the resources it owns [42]. Information is seen as an important resource to firms [43]. Even if the platform could bring market information or insight to the surrounding small firms, the information could not turn into innovations or improvements without the organizational capabilities. For these reasons, the relationships among strategy orientation, capability, the platform, and empowerment are proposed as P2-2.

P2-2: The strategy orientation and capabilities moderate the effect of platform on empowerment for participants in a service system.

5.3.2. External Factors

Two factors, governance policy and information liquefaction, externally mediate the impact of the platform in terms of empowerment. A service system needs a governance mechanism. For a service system made up of SMEs, the governance mechanism is much more important, because it helps construct or arrange a network structure for their coordination. However, Huggins & Johnston [44] mentioned older industries always suffered from path dependence and lock-in (*i.e.* inertia). Lin & Zhang [45] suggested a successful network must fit the dynamic requirement of the industry to preserve its competitive advantage. This would hurt firms' competitive advantage in a service system. In general, for SME owners who are rationally bound and ordinary people, adjusting the network structure organically is very difficult unless there is a platform acting as an information facilitator and a network governor, such as with the iTunes store or eBay.

Besides a clear governance policy, information liquefaction is the other external factor influencing firms' ability and intention to make behavioral changes. Normann [28] and Lusch *et al.* [46] argued organizations could better adapt by being able to liquefy information resources. The information could be liquefied through digital communication, networking, or other more efficient communication tools. If the information is liquefied in a service system, the governance policy would be more efficient and effective. P2-3 is proposed as below.

P2-3: The platform makes the governance policy of a service system clear and makes information liquefying, and then the effect of empowerment is generated.

5.4. Adaption among the Participants

As Huggins & Johnston [44] mentioned, path dependence, lock-in or inertia always appear in older industries. While the environment is stable, the unchanged network could be a source of competitive advantage for the industry and the firms within the industry. Due to information technology, "change" has become normal around

the world. This is especially the case for services always provided by a group of service firms that are a response to a specific part of the service.

Unlike a manufacturing product, the service industry is always facing a rapidly changing environment, especially the consumers' taste or preference, so the group of service providers should rapidly reorganize their network structure to respond to the changing demand. In sum, the adaption means that the structure of the value network is flexible to adjust to the environmental changes or for seeking improved competitiveness. **Table 3** provides evidence from four cases to support proposition P3-1.

P3-1: The characteristic of adaption makes the service value network flexible to adapt to environmental changes. The environmental change (economic, political, social, and technological) implies the optimal structure of the service value network must also be changed. For efficient and effective co-creation, establishing new and renewable inter-participants relationships are critical to a flexible service value network structure.

5.5. Drivers of Platform's Adaptation

Why does the platform have the characteristic of adaption? For the basic assumption of the service created by a value network, it implies a platform needs more participants to join and enlarge the potential for service productivity. For this, three major aspects that could be altered by the platform to establish the adaption are proposed. They are subjective evaluation of perceived risk and value, communication and transaction cost. These three drivers were elaborated for establishing three relevant theoretical propositions.

5.5.1. Driver 1: Perceived Risk and Value

In general, deciding whether to join a new service value network involves the issue of new business ventures. In terms of ventures, Forlani and Mullins [47] found a significant relationship between perceived risks and venture decisions. According to their research findings, entrepreneurs would not choose ventures with a high degree of variability in their anticipated outcomes. Building a stable and predictable environment is important to attracting new participants.

Given perceived risk (variability) and value (outcome) do matter for new entrants, forming a service value network through platforms such as 7-11, Hollywood or iTunes is a better approach than going into unknown ter-

Table 3. Evidence of a platform empowering participants.

Platform	Actions	Who are empowered	The results of empowerment
7-11	Translating market information to small firms.	Small firms (suppliers) Customers	To respond to the market quickly.
	To connect with their suppliers closely.		Shortening the time period of introducing new products.
	Introducing services to enable customer participation, for example, "ibon" in Taiwan.		Broadening the scope of service offerings. Changing customers' daily behavior.
eBay	Creating an organic eco-system for empowered buyers and sellers	Number of sellers and buyers	Scale of sellers and buyers brought abundant transaction items into the system.
	Worldwide replication of the service model	Diversification of sellers and buyers	
Hollywood	Constructing a movie producers' network	Changes to the eco-system	Emerging new service firms (for example, 3D or animation studio) to fit the technical requirement of new movies.
	Accessing market information through the main producers.		Innovative type of movies (3D or animation). New type of services, for example, DVDs.
			Changing consumers' purchase behaviors.
iTunes store	Creating a centralized eco-system for empowered buyers and content providers	Categories of service offering	Changing the distribution system of digital content.
	To connect the system with popular devices (iPod and iPhone)	Consumers	More and more innovative APPs and programs of good quality appearing.
		Suppliers	Bringing new opportunities to create new devices (iPad).

ritory or creating and accumulating networks gradually. These platforms provide potential participants with almost perfect information, chances to connect to stakeholders, a well-designed mechanism for building a more stable and predictable environment, and other advantages. The existence of a platform allows more predictable anticipated returns and lower variability. Thus, creating a service value network through platforms effectively decreases perceived risks in attracting potential participants, and then creating more opportunities for the appearance of new services and higher service productivity.

P3-2: The platform could reduce the perceived risks and enhance the value of participating in a service system and fostered its characteristic of adaption.

5.5.2. Driver 2: Communication Cost

Bolton and Dewatripont [48] noticed the influence of communication cost on organizational forms. They argued a firm appears to construct a communication network for decreasing communication costs, but the enlarging scale of the organization may offset the communication efficiencies by increasing communication costs. Most cooperation and coordination require a lot of communication to clarify the details of contracts to ensure parties' consensus. A platform could gather relevant firms which were needed for creating a service, for example, the Hollywood files production. A screenwriter could easily find a group of relevant firms for producing a file. Since the communication costs are reduced, then adaption is more likely to occur. A platform introducing IT technology could largely reduce communication costs, as with 7-11, eBay or an iTunes store.

P3-3: The platform could largely reduce communication costs to achieve a high level of performance and efficient interaction to improve the adaption of a service system.

5.5.3. Driver 3: Overall Transaction Cost

As mentioned above, attracting more firms to enter the service system and connecting to one another provides opportunities to utilize operant resources to create new services. However, attracting capable firms and renewing the structure of a network always involves uncertainties and risks which would cause losses to adapting firms. From the perspective of organizational economics, the aim of organizational design is minimizing the transaction costs occurring in organizations. Transaction costs refer to the cost of searching for information, coordinating with others, and monitoring and evaluating transactions [49]. Searching for a partner and evaluating if a partner is suitable is a complex process [50]. Higher such costs impede new firms from entry and existing firms from establishing new connections and relationships. A platform could help outside firms save on such transaction costs as entering the service value network and existing firms can establish new cooperation networks.

In terms of the four cases, iTunes offers a well-established and transaction-saving mechanism for the platform owner, APPs providers and consumers. Hollywood also reduces such costs through the main film producers. Like iTunes, eBay also created an efficient and effective environment to reduce the overall transaction cost of the system. 7-11 also demonstrated its ability to be an information hub and coordinator to lead surrounding firms to adapt to changes in customers' tastes and preferences.

P3-4: The platform reduces the overall transaction cost of a network. Transaction cost refers to the searching, bargaining, and evaluation costs due to the uncertainty of transactions.

5.6. Sustainability of the Service System

Basically, the term "sustainability" is easy to understand, but it is not easy to conceptualize, measure and formalize [51]. So far, the term of sustainability has referred to ecological and economic dimensions [52]. The purpose of industrial ecology is to evaluate and minimize the impacts from economics activities on the environment [53]. Here, the concept of ecology describing a positive loop in a group of service stakeholders, including the consumer side, is borrowed. Based on a positive development loop [54], the service system could sustain improvement in terms of effectiveness, efficiency, innovation, and industrial growth. Empowerment and adaption as the drivers of sustainability are considered especially in terms of helping firms to face obstacles to innovation [55]. To synthesize the evidence on empowerment and adaption, as shown in Table 2 and Table 3, P4-1 describing the relationships among empowerment, adaption and sustainability is proposed. Some evidence relevant to P4-1 is integrated in Table 4.

P4-1: The characteristic of sustainability, driven by empowerment and adaption, leads to sustainable development of a service ecosystem.

5.6.1. Vitality as a Mediator Bridging Empowerment, Adaptation, and Sustainability

Through empowerment, participants have been made more capable decision makers, but how they implement decisions they have made is still a big problem. It implied that there are a gap between empowerment stage and sustainability stage. The vitality of the service ecosystem is seen as a critical mediator between empowerment and sustainability. Vitality is referred to in the literature as involving urban public design and firm innovation. According to Jalaladdini and Oktay [56], vitality refers to “a safer, more desirable, and more attractive space which has the capacity for offering more choices for social activities as well as being a place for cultural exchanges”. The definition somewhat captures the nature of vitality, including an attractive space, as well as more choices and exchanges. In terms of firm innovation, Gnyawali and Srivastava [57] also advanced the concept of vitality and applied it in the context of a cluster and a network. They referred to the vitality of cluster and network as “the extent to which a cluster is imbued with new knowledge resources over time”. In their definition, new knowledge resources are the target measured to evaluate the extent of vitality of a cluster or network. Gnyawali and Srivastava [57] treated it as a catalyst for firm innovation. Gnyawali and Srivastava’s definition somewhat echoes the SDL’s viewpoint on operant and operand resources. Vitality can be found in the four cases given here. The buyer and sellers on eBay and in the iTunes store actively joined and sought out dealers. The

Table 4. The evidence of a platform helping to achieve sustainability.

Platform	Empowerment and adaption conditions		Level	Results in terms of sustainability
7-11	Empowerment	Co-existence philosophy	Strong	7-11 involves a wide range of services such as foods, commodities, books, and telecommunication. New services emerge continuously. High brand loyalty
		Extensive sale force		
		Information technology		
		DIY services for their customers		
eBay	Adaption	Delivering market information to small firms	Middle	7-11 is an organic organization which is always responding to environmental changes
		Connecting to other firms		
		Involving customers in the service process		
	Empowerment	Cooperation with complementary service companies	Strong	Continually internationalizing eBay into world countries
Hollywood	Empowerment	Information technology for searching and auctions	Strong	Business scale is growing in terms of number of employees, sale items, revenue, and etc.
		Create an organic eco-system for empowered buyer and sellers		
	Adaption	Worldwide replication of the service model	Middle	Continuously improving auction services for transaction convenience and safety High turnover rate of sale items to maintain novelty for users
		Main producers as coordinators and channels between customer side and supply side		
iTunes store	Empowerment	Empowering an old story to create market value	Middle	Keep innovating with movie productions such as 3D movies and business models (DVD, original soundtrack, and etc.) Being a main player in the global movie market for a long time
		Constructing a networking for cooperation		
	Adaption	Accessing market information through main producers	Strong	New players, for example Pixar Animation, emerged to support innovation in movie production
		Collecting APPs on a platform		
iTunes store	Empowerment	Enriching the content pool by introducing others’ content.	Strong	Accumulation of content Upgrading the value of the music service
		Information technology		
	Adaption	A mechanism for rapid feedback from users	Strong	Creating industrial growth Attracting more and more content creators
		Creating a centralized eco-system for empowered buyer and sellers		
		Creating a cross-device platform		Enhancing innovation in the APPs market

^aThe evaluation of the level of empowerment and adaption is based on the results of empowerment and adaption referred to in Table 2 and Table 3.

other unknown auction platforms that eventually disappeared were less active than eBay and the iTunes store. In Hollywood, agents also have to build connections with main producers to seek opportunities to join the movie producer team. The service system of 7-11 contains customers who are part of a service system and have high acceptance of innovation, with a large number of firms. The proposition relevant to the vitality is proposed below.

P4-2: The characteristic of empowerment positively affects adaption and sustainability through the vitality of a service ecosystem.

5.6.2. Diversity as a Mediator Bridging Adaption to Sustainability

A service ecosystem should adapt to the environmental changes for achieving a sustainable ecosystem. The change process always involves a term of evolution or progress. Given adaption is defined as the participants in the ecosystem reorganizing their network structure or establishing a new one, how an adaption leads to sustainability remains unknown. To address this, diversity is considered a mediator in this framework. Other scholars in relevant areas agree with this idea. Pirages [58], who discussed the issue of social progress, considered genetic and cultural diversity as important to social progress, because they make people and societies resilient to new challenges.

Scholars studying the issue of business ventures also applied information diversity to explain the relationship between business idea generation and divergent thinking [32]. They found information diversity could positively moderate the impact of divergent thinking on business idea generation. Business idea generation also positively influences venture growth. These two studies point out diversity is crucial for both long-term evolution and short-term creation.

The evidence related to the diversity is easily found from the cases outlined here. The iTunes store, eBay, 7-11 and Hollywood all did well in gathering many buyers, sellers, Apps developers, or SMEs to facilitate the effect of adaption. According to the literature reviewed above and the case evidence, the relationships among adaption, sustainability and diversity as P4-3 is inferred.

P4-3: The characteristic of adaption positively affects sustainability through the diversity of a service ecosystem.

6. Managerial Implications: Platform Service System Development Strategies

According to the cases and propositions examined here, a framework was constructed by an ultimate goal, sustainability, and two vectors of empowerment and adaption. The space formed by two vectors was divided into four grids denoting different status service systems. This framework also shows the three strategies to sustainability in Figure 4.

The first strategy is a path going through empowerment and adaption in sequence. The iTunes store and eBay followed this strategy. The second strategy increases their empowerment and adaption at the same time, such as with 7-11. The third strategy demonstrates a path going through adaption and empowerment in sequence, such as with Hollywood. These three strategies are named IT-driven, IT-market-driven, and market-driven, as Figure 4 shows.

The factors of a service system or industry would be changed as our model showed, if a service system or industry employ the emerging platform approach no matter what kind of strategies was be used. However, different strategies have somewhat differences in terms of the path of development progress (as we shows in Figure 4) and the time needed to achieved sustainability and higher service productivity. How the paths of three strategies are different would be explained in next section.

6.1. IT-Driven Strategy

The IT-driven path means a platform service system development strategy largely dependent on IT technology. The feature of the strategy follows the steps of 1. empowerment → 2. adaption → 3. sustainability. Sometimes, due to the imperfect market or bounded rationality [59] of humans, solely introducing the IT enables the creation of a platform to facilitate market transactions. For example, eBay and the iTunes store are classic cases of an IT-driven strategy. IT technology helped everyone overcome the bounded rationality of humans to deal with someone in the world. Clearly, eBay and iTunes could not have done this without IT technology.

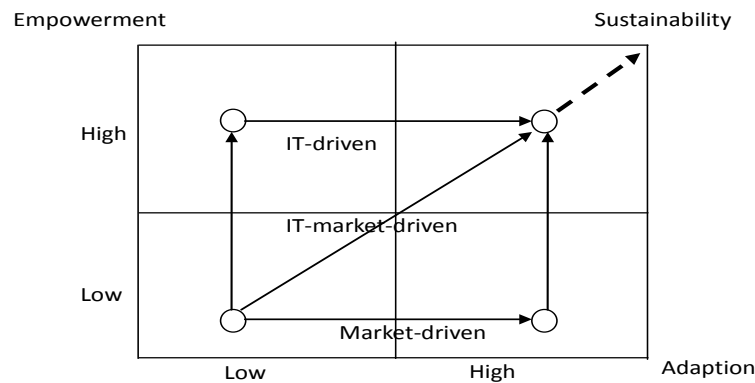


Figure 4. Three strategies for service system development.

6.2. IT-Market-Driven Strategy

An IT-market strategy means a platform using IT technology to support the management of a service network. In this situation, IT technology is a catalyst in the platform service system for achieving sustainability. 7-11 is a typical case for understanding an IT-market-driven strategy.

6.3. Market-Driven Strategy

The third strategy to sustainability is the market-driven strategy. This strategy means the platform service system is formed by a market mechanism. Like Hollywood, it largely depends on the market mechanism to build a cooperation network. Hollywood connected the demand side to the supply side through the main producers' coordination. It could move toward sustainability by the path of adaption—empowerment, but a lot of time is needed.

7. Conclusions

In this paper, the theoretical model argues applying the concept of platform to design a service system could improve service productivity. While the concept to manage a service system is used, three effects, empowerment, adaption, and sustainability, should occur. These effects are also a set of criteria to evaluate the level of how healthy a platform is. According to the three effects and cases, three basic development strategies are proposed. They are the IT-driven strategy, IT-market-driven strategy and market-driven strategy. Although these three strategies are alternatives to one another, it is believed that the IT-driven strategy is better than others in most situations.

The model can also assist academics and decision makers. For the academic research, a new concept for platform service system development and criteria for its management (*i.e.* empowerment, adaption, and sustainability) are proposed. It also suggests some future research directions. First, a new notion of platform service system and its theoretical foundation and process are given, but a substantial tool to realize the theoretical process and outcome is lacking. Second, a rigorous empirical study could make an emerging theory more solid and reliable. Third, exactly how a decision maker selects one of the platform service system development strategies is also an interesting research issue. For decision makers in a service industry, this model describes how the environmental conditions and processes work for higher service productivity.

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Portraying the Social Dimensions of Consulting with Structuration Theory

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Abstract

In this paper, we argue that the consultant-client relationship is of central importance for consulting engagements. The paper therefore outlines the social dimensions that are inherent in the consulting system due to its characteristics that create social complexity. To gain further insights into the social interaction scheme and dynamics of consulting projects, a conceptualization based on an appropriate theoretical model is required. We propose to utilize the Structuration Theory for the compilation of the social context of consulting, as this provides a framework for incorporating the social determinants, focuses on actions of human-beings, and additionally allows the identification of interrelated dependencies of structure and actions.

Keywords

Consulting, Consultant-Client-Relationship, Structuration Theory, Consulting Research

1. Introduction

Consulting as a phenomenon of interaction between people in terms of counseling or giving advice has been existing since people live together, why consulting is sometimes called the “oldest profession” [1]. However, for this paper, an orientation on a generic but more purposeful definition of consulting in a business context is required. Consulting in the sense of this contribution is, in accordance to Nissen [2], defined as a professional service that is provided by one or more persons, who typically have the required expertise to solve the problem at hand and are hierarchically independent of the client organization. The consulting engagement is limited in time, financially compensated and has the objective to define, structure and analyze business issues of the client organization interactively with the client’s employees and to develop corresponding solutions as well as to implement them in close cooperation with the client if requested.

The consulting industry has seen a considerable growth over the last two decades. In Germany, for instance, the total turnover has risen from 12.2 billion Euros in 2003 to 22.3 billion Euros in 2012 [3]. This is likely to continue, as companies are continuously forced to find appropriate organizational and process-oriented answers in an environment of dynamic and ever-changing markets and regulations. To handle those challenges that lead to high management complexity, companies feel urged to use consultants and involve external business-related and methodical expertise [4]. This enabled the consulting industry to institutionalize its business segment of creating, sharing and verifying knowledge [5]. Sociologists consider the increasing weight of the consulting profession as an example of the general shift to service sectors in industrialized economies. Today the consulting industry is recognized as an influential emerging profession to which certain business tasks of an organization are given [6]. Based on its impressive growth the consulting sector gains increasing influence not only on virtually all other branches of industry but also on social and cultural areas [7] [8].

Though the intensity of interaction between consultant and client differs in the variety of consulting engagements, it is beyond controversy that any consulting engagement requires a certain level of cooperation between consultant and client to solve the problem. Along that point of view Reineke and Hennecke add that the consulting process is basically a meshwork of interactions between the involved human beings that will result in a variety of personal relationships [9]. Consequently, Timel highlights that ability and willingness to cooperate is a critical indicator for professional work for both the client and the consultant [10] [11].

Thus, consulting should be seen as a complex social activity. The success of consulting strongly depends on the relationship and interactions between consultants and clients within the consulting project [12]. This interaction, however, is not well understood so far. A better understanding of this relationship would offer opportunities to increase the chances of consulting success. On a more general level, we believe that a sound theoretical basis for consulting in the sense of consulting research [2] can help to improve the often rather shirt-sleeved way consulting is conducted today. This would have a positive impact on the client as well as on the consultant side and potentially improve the professions rather damaged reputation.

This motivates our research that aims to provide a social framework for consulting interaction and illustrate the determinants that create social complexity and uncertainty of consulting services. It is intended to enhance the business economic view of consulting services by a sociological perspective. Based on a literature review we first explain the modalities of consulting services in order to outline the theoretical perception of the research object in question. For that purpose the typical activities of consultants are briefly outlined in Section 2, whereby consulting services are characterized as complex social phenomena. In Section 3, the significance of the consultant-client-relationship and the imperative for trust are highlighted in order to grasp understanding about the given inter-dependencies.

It will be argued that for further investigation of the consulting context, an analytical and explanatory theoretical framework is required for making valid statements about the social interaction schemes in consulting. For that purpose, the requirements on the theoretical conception of consultant-client interactions are outlined in Section 4 and the essential theories that have been applied already to the consulting context are briefly recapitulated and evaluated with regard to their explanatory potential. Consequently, the Structuration Theory is proposed to provide substantial insight. After having introduced to the basic principles of Structuration Theory in Section 5, it is illustrated in Section 6 how the consulting system is perceived in the structural modes of signification, domination and legitimation. Finally, in Section 7, some conclusions and reflections on the use of Structuration Theory in this context are given.

2. Consulting Services as Complex Phenomena

The various functions that have been assigned to consultants in the academic literature in context of their engagement have been summarized by Kolbeck as neutrality, knowledge-sharing, efficiency and a legitimization function [13]. With that list however, the functions are illustrated from a self-evident and superficial perspective. The view on the more specific intentions of an organization for engaging a consulting firm reveals a wider set of purposes that do mainly reflect the consultant as an instrument for the organizational game. Beyond the sole use of consultants for solving business issues and gaining creativity, they are frequently engaged from the buyer to demonstrate capacity to act, finding arguments that support a decision that is already taken as well as to displace the responsibility for decisions and failures to the consultancy instance. Therefore, consultants are often used to strengthen the own hierarchical power of the buyer [14]. This indicates already a tough micro-politic terrain in

which the consultant needs to act.

Regardless of the different functions behind the consulting engagement, there is a typical set of tasks which consultants carry out during consulting projects. Appelbaum and Steed have consolidated the consultant's classical activities to the following list, which gives an overview about consultant's missions and client's expectations as well indicates the variety of social profiles the consultant must obtain [15]:

- 1) Providing information to a client
- 2) Solving a client's problem
- 3) Making a diagnosis
- 4) Making recommendations based on the diagnosis
- 5) Assisting with implementation of recommended actions
- 6) Building a consensus and commitment around a corrective action
- 7) Facilitating client learning
- 8) Permanently improving organizational effectiveness

Despite the various fields of engagement possibilities, there are certain characteristics of consulting services. The nature of consulting is that of a weakly pre-determined and complex domain. Complex systems are basically associated with the attributes of unclear and volatile path developments, various sources of irritations, multiple dimensions of pressure, inherent risk and distributed areas of action [16].

Consulting services show general convergence with these attributes: the actual consulting service as the product is to be concretised while the consulting processes are carried out based on interactions with the client. The directions on the way to the final consulting result are thereby significantly irritated by several bases of expectations from both the client and consulting organization [17]. Moreover, most of the consulting projects are faced with considerable time pressure that creates additional tenseness [16]. A certain portion of risk is always inherent to consulting projects, too. This originates from the structural input-output uncertainty that is typical for services in general, as those are provided by incorporating external factors of production [18].

The consulting context is discussed in the academic literature by highlighting four major characteristics [19]. **Inseparability** means that buyer and seller of a consulting service must interact to refine the consulting process and thus the actual delivery. A high level of interaction intensity is required in combination with relational exchanges whereby the client's needs are established by the consultant and the consultant's professional ability and quality are assessed by the client. In the information-exchange process, personal relationships are important to enable creation of implicit interpretations and obligations as well as to develop trust [19] [20]. Intense interaction can also be viewed as the need for overcoming information asymmetries on both sides: the consultant's uncertainty about the specific form of the client's demands; and the client's uncertainty about his choice of the right advisor and the consultant's approach to solve the client's issue [19].

The consulting service is also attributed with **intangibility**, even at a higher degree compared to most other services. Intangibility means that services do not take the form of a material product. The consulting service cannot be sampled before the purchase and there is no possibility to reproduce any service that has been already delivered in other situations [19]. This comes along with significant difficulty for the client to assess the capabilities of the consultant ex ante and to evaluate the service quality even ex post [21].

Heterogeneity of consulting services refers to their generally very low level of standardization. Consulting Services usually require the re-tailoring to each client in a process of uniqueness. This again leads to problems of quality control as well as the need for the client to be closely involved in the service creation process to check appropriateness. In that context Clark argues that a large part of the client assessment of appropriateness may depend on client's impressions of the services delivered by the consultant. In turn, the consultant strives to manage those impressions with trying to sell the consulting work most positively to the client [19] [20].

A further characteristic is seen in the **perishability** of the consulting service. This occurs since the creation process for consulting outcomes is dissolved after the consumption and needs to be started by new at another consulting engagement. The consulting result, including some of the intellectual property rights, is transferred from the seller to the buyer and can be utilized by the buyer internally. Although repeat business often occurs, the new consulting engagement will again require new tailoring and will therefore produce new contingencies [19].

The perception on the role of consultants is currently going through a paradigm shift, as significant cutbacks through consolidated consulting projects, changing client expectations as well as increased demands and pressures on consultants have been recognized. Consultants find themselves challenged to provide a wider range of

services than they did in the past, including implementation, and the need to match goals with results. It becomes obvious that the rather perishable facets of consulting services must be made much more tangible, long lasting and highly apparent to the client [22].

The consulting market is characterized by a high level of intransparency, which causes a high amount of transactions costs to gain a market overview and to identify the best consulting offer for certain demand [23]. The main determinants for consulting competition are experienced-based trust and reputation [24]. As a result consulting is to a big extent driven by repeat business. It is not primarily about winning one single consulting project at a certain client, but steadily doing business with this client. Consequently, consultancies aim for creating a long-lasting and trustworthy network of client relations, which will be the major fundament for their growth, competitiveness and market success [24].

3. Significance of the Consultant-Client Relationship and Imperative of Trust

Irrespective to the actual role of the consultant, whether he acts more as a coach or a supervisor or as an expert, the consulting situation is always determined by the clash of two parties with different interests. The client has the demand to find efficient support for solving his specific problems, whereas the consultancy acts as supplier for a profit-driven service. The relationship between client and consultant is therefore attributed with the respective expectations, restrictions, negotiations and agreements [25]. Generally, consulting can be considered as a socially and culturally contextualized business.

From a system-theoretic perspective, the actual consulting event, determined by the single steps of actual consulting processes, is embedded in a framework of certain social patterns [26]. In the way the client and consulting organizations develop patterned ways of behaving in their respective proprietary systems, the same applies for the consulting system: both consultants and clients develop certain patterns of dealing with each other. While the consultant and client interact, the consultant-client nexus becomes its own system that is subject to the same system realities as any other. The emerging logic of the consulting system infuses the consultant-client relationship reciprocally. With modeling a system-theoretic intervention by the consultant in the client organization, this basically reveals a fundamental dilemma in the mode of conduct: the client system attains to the outside of their boundary to seek for consulting support. Reversely, the engagement of consultants constitutes the creation of a new consulting system, which could restrain the consultant's access to the client organization as well as his external objectivity [27].

The building of the consulting system reflects further general social system characteristics with typical rituals and themes. In the early phases of the consulting system, Gemmill and Wynkoop describe that both consultant and client have a mask, meaning that there is a portion of themselves which they consciously try to keep secrete. A psychodynamic observation shows the frequent existence of a high level of resistance and hostility on both sides toward the other group, with sometimes even casting the others into the group of enemy. A given high degree of resistance and hostility on the client side leads to identification problems of the consultant and discourages him to proactively diminish these social barriers. Defensive response by the consultant could be a result, which will in turn have a destructive effect on the continuing of the consulting processes [28]. Moreover, in the way of forming the consulting system the consultant and client need to deal with the allocation process for power and trust relations. The group of consulting participants, therefore, experiences several stages of crisis and different emotional states. So, a further important step is to learn when to take on social conflicts and how to solve them [29].

The consulting interactions can be further-on perceived as processes of negotiation and exchange. Exemplarily, the consultant in the role as initiator expresses recommendations, which the client can then decide about whether and how they should be implemented. In this regard, power is considered as the platform that determines what flows into the interactions and how it is adopted [30]. At first the buyer has the power to select an appropriate consultant and to assign him a respective role [31]. During the consulting project there is high risk of power conflicts that arise as power is associated with expertise and experience. Consequently, status claims start to exist as soon as multiple parties interact in the consulting system. Hereby, power can be expressed with setting directives or demonstrating resistance [32].

The inherent complexity in the consulting system is seen to be significantly reduced when social capital is created [33]. Social capital is defined by Leana and van Buren as "...collective goal orientation and shared trust, which create value by facilitating successful collective action" [34]. The social capital of a consulting project

consists of obligations and expectations concerning the accomplishments of the project mission and reflects the capability of the project members to learn and innovate. Consequently, the social framework with causal ambiguities, adverse interests, conflicts and legitimacy issues needs to be in focus for forming a functioning consulting system (compare to approach of Sydow and Staber [35] in a different context).

Consequently, the interactions between consultants and clients and, hence, the focus on individuals are the crucial drivers for consulting success. Constant communication is required ensuring that the specific context of the client organization can be incorporated into the development and implementation of solutions [4]. Consulting is thus, to a large extent, about forming relationships. The consulting processes are considered to be effective when the consultant was able to build a productive and sustainable relationship with the individuals of the client's company [12].

As immateriality, impossibility of preceding performance assurance, unspecified services and high interactivity are constitutive features of supplying business services in general, trust is highly meaningful, especially in this economic segment [36]. Consulting is often characterized as a trust object, since the client needs to rely on the expertise promised by the consultants in advance of the project and the consultant's performance is also difficult to be evaluated even after finishing the project [11] [37] [38]. The client generally has a twofold attitude towards the consultant: enabling the consultant to act as an advisor and having impact on the client organization. Therefore, a respective level of personal proximity is to be admitted by the client if the consulting engagement is to provide meaningful, purpose-oriented results. In contrast, the consultant's own economic interest to maximize profit through the engagement and the hazard of opportunistic behavior indicate the need for caution and control. The client is therefore faced with critical attribution problems of what level of freedom can be granted to the consultant [39]. These problems are not controlled by a superior instance; as the consulting industry is not a traditionally regulated profession.

4. Requirements on the Theoretical Conception of Consultant-Client Interactions

As outlined in the previous sections, various social challenges must be overcome to achieve the desired consulting result. While the consultants and clients produce the consulting result via their interactions, they need to deal with emerging social dynamics.

As the characteristics and facets of the consulting system vary in occurrence and intensity from project to project and observations from single projects are unlikely to have equal meaning for another project, an abstraction via a theoretical model gains relevancy. A theoretical model in that context should deliver explanations why both the client and the consultant show the respective behavior in the consulting project. It should allow to conceptually reconstruct the interaction processes, should provide a comprehension of interaction patterns and deliver implications for a subsequent state of the relationship between consultant and client.

For the theoretical reconstruction, however, a sole descriptive portrayal does not appear to be sufficient, but an explanatory model is required which needs to incorporate the fundamental influencing factors that have effect on the social scheme of the consultant-client relationship. One should focus on motives why the participants of the consulting processes carry out their respective actions and what the intended and non-intended social consequences are. The perspective on the consultant's and client's intentions will allow reconstructing their behavior in a mode of ex post interpretation of rationality.

The action scheme of the consultant and the client shows a process of change and progress. Consequently, the social pattern of the consulting system cannot be grasped by constant parameters. A static orientation of the theoretical approach ignores the dynamic action scheme within the consulting system (compare to approach of Iding [40]). There is also the need to put attention to the irrational processes and unconscious dynamics that influence the behavior of those engaged in the consulting project [27].

Moreover, the basic constitution of consulting projects is to be understood as a temporary system. Its characteristics need to be interpreted in a system-related perspective, whereby the perception of the embeddedness of that consulting system into the superordinated systems is of great importance [41]. A multi-level orientation is required for the theoretical conception, since the layers of affiliations, environments, interactions and identities need to receive attention for a comprehensive perception of the social scheme of the consulting system (compare to approach of Lamb [42]).

Having outlined the requirements resulting from the social complexity and dynamics of the consulting system, it needs to be briefly evaluated to what extent the major existing theoretic streams are appropriate for portraying

those social dimensions. For that purpose a segmentation of theoretic streams will be used with the following grouping (similar approach of Hasenzagl [43]):

1) basis theory, 2) subject theory and 3) practice models.

On the level of base theories it has been mainly referred to the systems theory of Luhmann [44] (see exemplarily [11] [45] [46]) and the theory of neo-institutional economics of Williamson [47] (see exemplarily [48]-[50]). The systems theory models abstract findings on the behavior and development of systems [51]. In the context of consulting research it gained particular relevancy in the systemic consulting approach [2]. This approach considers the client organization as a system that cannot be influenced externally in a direct way; therefore the consultant is reduced to the role of an observer [52]. The social sphere of individuals has a subordinated role [53]. Consequently the systems theory does not appear to provide a theoretical platform for analyzing the social interactions between the consultant and client.

The theory of neo-institutional economics is based on the assumption that individuals strive to maximize their economic benefits in incomplete real market situations, which are determined by cognitive limits, incomplete information and difficulties in monitoring and enforcing agreements. Concepts developed in this context focus on information asymmetries and opportunistic behavior between economic transactions partners [51] [54]. In this theoretical framework, the model of transaction costs appears to have relevancy for providing explanation about the social interaction scheme of the consulting system, as this model is action-oriented and has been applied in several studies focusing on the consultant-client relationship (e.g. [6] [55]). In verifying its appropriateness, however, it becomes evident that the transaction cost model does not provide an adequate perspective on the specific sociological layers and elements that are required for explaining the social patterns of interactions. It bases on a sole opportunistic orientation of the actors and has a reduced view on the integration of various socio-analytical levels, specifically the interrelation of systems, actions and individuals [56].

Also the Structuration Theory is to be grouped into the section of base theories. This theory has not yet been applied to the context of interactions between client and consultant. The only noteworthy link of the Structuration Theory to consulting research in general has been provided by Schwarz [57] when using that theory to provide an understanding about the social terrain of the client organization for enhancing the effectiveness of consulting interventions. The Structuration Theory proclaims the duality of structure and action and, therefore, combines functionalistic and individualistic theoretical approaches. This theory is directly based on the social processes and emphasizes the significance of humans [58]. Consequently, the relevance of the Structuration Theory for the consulting system will be highlighted in the subsequent chapters.

The theoretical models in the segment of subject theories aim at creating a subject-specific comprehension of the research artifact. Subject models are not directly driven by any superordinated theoretical direction. In the context of the consultant-client interactions two specific models have evolved in the academic literature: the client-expert model [59]-[61] and the model of symbolic interaction [20] [62].

In the expert model, the consultant acts as an expert, identifies a client's problem and transfers knowledge "...while remaining an objective and neutral advocate of best practice" [63]. This model considers consulting as a unidirectional gathering process of information rather than as a real interaction [64].

The model of symbolic interactions, also known as the critical model, regards the consultant as the provider of institutionalized myths and rhetorician [62]. It mainly examines the process of knowledge creation within the consulting processes. Hereby, it states that consulting knowledge is developed in interaction with the client and is ambiguous as well as symbolic. Images, stories and symbols serve as "rationality-surrogates" and constitute consultant's real expertise [64]. It is argued that both models stress single features of the client-consultant interaction, but they do not recognize its multidimensional and complex character [65]. They are thus not assumed to provide a comprehensive and analytical perspective on the consultant-client interactions.

Finally, practice models mainly originate from observations of various situations in the consultant-client interactions, partly supported by empirical methods. Examples in the literature are Maister *et al.* [66] and Cope [67]. They mainly have a descriptive approach with capturing the specific context of the focused situations. However, they do not allow deriving valid statements or providing proper explanation on a generalized level about the interrelations and intentions that initiate and shape social actions within the consulting system.

5. Applicability and Basic Principles of Structuration Theory

As was highlighted above, a high level of social complexity is a characteristic feature of consulting. Issues of

social legitimacy, tacit knowledge, micro-political interaction schemes, sense-making processes as well as the resource and path dependencies along with general interest conflicts have to be considered when examining the consultant-client interactions.

In this research work, the application of the explanatory framework of the Structuration Theory for the analysis of the social dimensions of the consulting system is proposed, as it integrates the required multi-level, processual and dynamic perspectives of the consulting system and focuses on both the interactions of the individual and collective actors. As the actions of human-beings cannot be described with fixed rules, the Structuration Theory provides interpretations schemes for social practices.

Referring not only to the economic context but also to the social dependencies within consulting projects can help to better overcome inefficiencies in consulting projects. Structuration Theory is expected to allow for the integration of essential success factors from a social context. As the focus on human actions is emphasized, this theory looks behind the conscious and unconscious intentions of consultant's and client's actions and abstracts how the consultant and client build their joint structures. Consequently, Structuration Theory can act as an analytical platform for doing a focused analysis on social facets, such as the investigation of trust between consultant and client.

The theory of structuration has been proposed by Anthony Giddens (1984) in *The Constitution of Society* [68]. Giddens basically argues that actors (described as human agents) and social structure (rules and resources) are interrelated. Structure is thereby reproduced by repeated actions of individual agents taking place within a structured framework [69].

This contrasts with the deterministic perspective on structure of others in the literature which assumes that structure is impervious to human agency [70]. It informs and constrains the activities of actors instead of being recursively created and recreated by the actions of human agents. Determinists believe that only past and present determine the level to which humans have an influence over their future. Giddens rejects the determinist view with arguing that human beings should be able to identify laws that will predict how societies will develop [69]. Consequently, Structuration Theory aims to avoid the extremes of a strict determinism through structure or agent. Instead Giddens aims to balance both structure and agent.

Social structures are created and shaped as a result of the recursive interactions between institutional structures and individual actions. Giddens states that structures are "both the medium and the outcome of the practices which constitute social systems." [71]. Giddens' defines structure as a set of rules and resources, recursively implicated in the reproduction of social systems. Structure exists only as memory traces, the organic basis of human knowledgeability, and as instantiated in action [68]. In Giddens' view, structure is constituted by rules and resources, which are both governing and available to individuals.

Giddens has identified three types of structures in social systems: signification, legitimation and domination. Signification creates structure with producing meaning through organized webs of language, which could be semantic codes, interpretive schemes or discursive practices. Legitimation produces a moral order via immersion in societal norms, values and standards and therefore serves as code of conduct. Domination produces power and is at the same time an exercise of power, which originates from the control of resources. These structures are interrelated and create and reinforce our complex social reality [69].

From the Structuration Theory perspective, rules are techniques or generalizable procedures applied in the production or reproduction of social practices. This definition refers to communication codes and linguistic rules, valid organizational norms, technical directives and other rules drawn upon in social interactions. With regard to their appearance, rules can be codified and articulated as a policy and bureaucratic rules, but can also exist as unarticulated background knowledge such as rules of interpretations. Resources signify capacities to create command over material and social objects with generating power. Resources refer to the capacity to affect material objects and means (allocative resources), as well as nonmaterial capacities to harness the activities of other individuals (authoritative resources) [69].

As Structuration Theory has its focus on the doing and being of the individuals that carry out social interaction, the concept and role of the actor (as agent) needs to be illustrated in more detail. Giddens states that individuals are knowledgeable. This implies that people know what they are doing and how to do it. It also means that people are capable of using their knowledge to act in creative and innovative ways, and consequently transform the structures (rules and resources) within they work [69]. The knowledge of rules refers to the ability to apply them in unfamiliar circumstances, as opposed to simply have relevancy in routine circumstances. As a consequence, agents have control over their social relations and can influence those in some extent. The agent

then has the ability to rearrange, apply and extend rules to new environments [70].

Therefore, agency refers to the volitional character of human actions, meaning the capability of individuals to act with conscious intention [68]. Consciousness implies that human beings can and do monitor the domains of social actions within which they operate. They particularly monitor their own actions and their consequences, the actions of others and also other environmental aspects. This ability for monitoring the domain of action bases on two levels of consciousness: practical and discursive. Practical consciousness is the capability to maintain a continuing theoretical understanding of the grounds of their social activity. Human agency thus exhibits what Giddens calls the rationalization of action. Usually, people know more as what they can say [69]. Discursive consciousness, on the other hand, is reflexive, focusing on the “monitoring of that monitoring of action”. Discursive consciousness is the capability to explicitly describe intentions that determine actions as well as the reasons and motivation for action. These two levels of consciousness are steered by motivations located in the unconscious of agents that aims to find psychological security. This need can explain by a big extent why agents routinely reproduce social structures that they even interpret as excessive bondage [69].

To determine how agents interact, Giddens uses the analytical distinction between the three types of social structure: signification, domination and legitimation. These structures are built up by the structural properties of norms, sanctions, communication, and interpretative schemes. However, Giddens points out that in any concrete situation of interaction [e.g., such as in an organization], actors make use of these structures and structural properties as an integrated set and not as separate structural units [69].

The signification structure is linked to organizational interaction by different kinds of interpretative schemes. These schemes are the cognitive means by which actors makes sense of what others say and do and are one of the modalities of structuration [69]. Therefore the signification structure could be used by agents for communication and understanding and, in the long run, to provide some sort of meaning for different types of activity [72]. The modalities work as a catalyst between the overarching social structure and the day-to-day activities of an organization. As Giddens puts it: “What I call the modalities of structuration serve to clarify the main dimension of the duality of structure in interaction, relating the knowledgeable capacities of agents to structural features.” [68].

The domination structure deals with various ways of exercising power using different types of resources. Power is divided into two classes. In the broad sense it refers to the transformative capacity of human action. In the narrow sense it refers to the medium for domination. In its broader sense power can be related to the ability to get things done, *i.e.* create activity. In the narrower sense, power is simply domination through, for example, an organisational hierarchy. According to Giddens, all social relations involve power in both the broad and narrow sense [68]. In specific time-space locations the capacity to exercise power can be related to asymmetries in the distribution of resources [73]. Both allocative and authoritative types of resources facilitate the transformative capacity of human action while at the same time providing the medium for domination [69].

Giddens further states that the legitimation structure involves the moral constitution of interaction and is mediated through norms and moral codes which sanction particular behaviours. It comprises the shared sets of values and ideals about what is regarded as important and what is to be regarded as trivial. **Figure 1** depicts the interconnected dimensions of Giddens’ duality of structure.

The interaction between the three modalities occurs simultaneously and is only separated at an analytical level. Through the interplay of these modalities (the process of structuration) human actors reproduce or (less frequently) change existing norms of behavior [74]. The key principle in Structuration Theory is the duality of structure

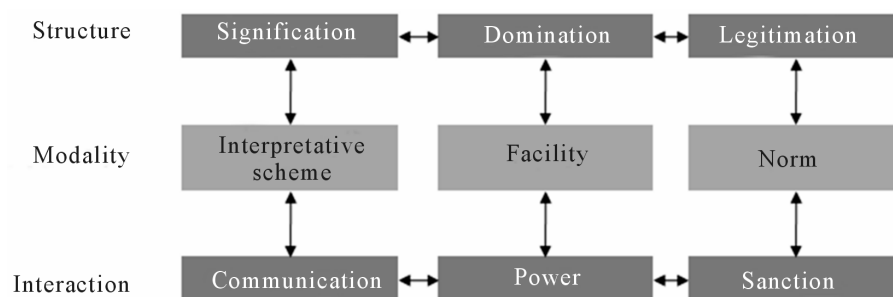


Figure 1. Dimensions of structural duality ([69], p. 29).

structure: human action is enabled and constrained by structure, but structure results from human action. Structure is thus both the medium and outcome of action that it recursively organized. The duality of structure in interaction can be understood as follows: Agents exercise power, communicate and sanction their own behavior and those of others by referring on modalities (stocks of knowledge, rules and resources), and in doing so produce and reproduce structures of signification, domination and legitimation [69].

The connection between social structure and human action refers to the process of structuration, the process by which the duality of structure evolves and is reproduced over time space [69]. This process is executed by three modalities: interpretive schemes, resources, and norms. Interpretive schemes are standardized and shared stocks of knowledge which humans reflect with interpreting behavior and events, and hence achieve meaningful interaction. Actors draw upon interpretive schemes that are mediated by communication. This does not only enable or limit communication, but with perceiving it in interpretive schemes, actors reproduce structures of signification. Resources are the medium by which intentions are realized, goals are achieved and power is exercised. Finally, norms are described as rules governing sanctioned or appropriate conduct, and they define the legitimacy of interaction within an order of moral setting. Norms thus enable and constrain action. With their invocation in interaction, actors create structures of legitimation [69]. These three modalities define how the institutional settings of social systems influence deliberate human action by affecting the manner how people communicate, enact power, and determine what behaviors to sanction and reward. They also determine how human action form social structures when the structured social practices are institutionalized [69].

Within society and within organizations there are discrete social systems of interaction. Examples of these within the general community might include religious groups and political parties. At the workplace discrete groups might include work units, for example the research and development unit or the marketing unit, and other groups such as the staff social club. Each of these systems works in its own individual way. Giddens described such systems as “The patterning of social relations across time-space, understood as reproduced practices. Social systems should be regarded as widely variable in terms of the degree of “systemness” they display and rarely have the sort of internal unity which may be found in physical and biological systems” [68].

6. Perceiving Consulting Services with the Modes of Structuration Theory

6.1. Overview

As the consulting project is embedded in multiple contexts there are structural conditions that influence how the consulting project is organized. Since each consulting project is a unique system, however, projects are to some extent independent from their environments and developed in idiosyncratic ways as a temporary social system. At the same time the consulting project as an own system relies on routines, norms and practices that are established in various systemic contexts and that both facilitate and constrain system organizing activities (compare to Manning [41]). Social systems, such as temporary consulting projects and their social contexts, are brought about by social practices of the consultant and the client through regularized activities based on which the actors apply (and reproduce) sets of symbolic and normative rules as well as allocative and authoritative resources. Consulting systems have “systemic boundaries” since structural properties can be identified that guide the actions in terms of specific (systemic) sets of rules and resources of the consulting project. With entering the consulting project both the consultants and the clients take up roles. The process of entering the project also comes along with uncertainty and risk. Both create anxiety for the parties. This anxiety results from the situation that both parties enter into new personal relationships, receive new tasks and deal with new routines [27]. The Structuration Theory hereby focuses on the recursive interplay of actions and structure and therefore provides insight how the relationship between the consultant and the client is constituted and embedded in a temporary social system.

A consulting project can usually not be considered as a closed circle of isolated activities, but is integrated in a system of social relationships towards the client organization and the consulting organization. Those have significant impact on the constitution of the consulting system, even though the project organization for the consulting processes has a distinct social identity and organizational culture. The consulting project, therefore, creates social capital that encompasses obligations and expectations with regard to the goals and activities, as well as reflects the capability of the project members to generate knowledge and innovation. On the other side, strained social relations can also create negative outcome in terms of stagnation and frustration. Consequently,

the consultant and the client are not only faced with challenges of delivering expected project outcomes based on applying methods of technical nature (like focusing of working results, budget and plans), they also have to cope with causal ambiguities, interests, conflicts and legitimacy issues that are typical for social relationships. The consultant and the client are also exposed to the usual social group building process and have to create the structures of the consulting system with engaging in power and trust. The consulting project passes through several phases of crises in order to become a matured group. In that context the consulting system also learns how to cope with conflicts and uncertainties to become more and more an independent unity that can increasingly act on their own authority [29].

The [re-]produced structures of domination, signification and legitimation of the consulting system provide the context for developing the respective portion of trust, commitment and reciprocity norms, which enable the coordination of the consulting project. Based on both the temporary character of the consulting project as well as the strong binding towards the client organization due to the mission of solving its problem, it is expected that a consulting project is only able to produce a limited scope and intensity of structural institutions on itself. There is a strong relation to the organizational scheme of the client organization, which enables inter-organizational actions, pronounces normative expectations and, consequently, provides the social context that constitutes signification in terms of meaning for the consulting project (compare to Sydow and Staber [35]).

6.2. Signification by Communication: Meaning and Sense-Making in Consulting

Signification describes the rules how meaning is constructed for the interactions between the consultant and the client. As signification refers to the cognitive order of a social system, it also includes the interpretation and perception by the consultant and client of how the consulting system works. As in other social systems, the agents of the consulting project interact with each other on the basis of their conscious or unconscious interpretative scheme, which can be individual perceptions of rules of order, missions or experienced sense-making logic. For the consultant and the client, it is vitally important to refer to those interpretative schemes in order to enable interactions during the consulting process and, as a result, produce enabling structures for the consulting system on its own.

On the client side the interpretative scheme is to be portrayed with contrasting it to the expectations that the client has with regard to the consulting engagement and the consulting project. Ojasalo has classified the expectations of the client into fuzzy expectations, implicit expectations as well as those that are unrealistic. Fuzzy expectations refer to the indefinite idea about the outcome of the consulting project. Ojasalo argued that clients do usually not have a precise idea of how the solution to be proposed by the consulting project should look and what the change in the client organization should be [75]. Also, what the client really wants is not necessarily what they actually say. Despite the fact that the client usually does not exactly know what he wants, he is regularly assumed to know what he does not want [76] [77]. Implicit expectations of the client as the second form are elements of the consulting service that are so self-evident that the client does not actively think about them, also not with regard to the potential that they do not materialize. Next to this, the client also bears a certain portion of unrealistic expectations, which describe those expectations that the consultant can hardly resolve due to the circumstances of the consulting situation and for which the consultant cannot be held responsible if they cannot be met [76] [77].

Abstracting these expectations towards the consultancy engagement to the higher level of the overall client organization, meanings and, therefore, signification structure is created with assuming the consultant to act as a trigger for thoughts that are present in the organization's life, but have not been expressed before. These are described as "un-thought known", which are inchoate and pre-conscious in everyone's thinking, but not acknowledged publicly in the client organization. The consultant is then expected to deal with these unexplored matters that are inherently present within the organizational system [27] [78]. Next to this, several aspects of consulting engagement motives can be summarized to the general intention of strengthening control of individuals within the client organization. This has particular meaning for the management level of the client company. Consulting projects are seen as mechanism to stabilize or enhance the individual control capacities with providing (new) information about external best practices or about the client organization itself to the client managers, which has not been available so far in structured form or no assessment has been done on them. This is why already information from the analysis phase of the consulting project is often perceived as valuable within the client organization, as this can provide new insights and strengthens the control capacity [79].

With considering signification structure as interpretative scheme from the consultant side, meaning for the consultants interactions during the consulting projects are constituted by the portion of acceptance and credibility he receives from the client during his engagement. The consultant is viewed as operating in a different arena in relation to his clients. Consequently his role and value is intimately tied-up with his ability to translate his knowledge and understanding of this outer context to his client [80]. Acceptance and credibility are crucial to enable effective intervention by the consultant in the client organization, which is essential for providing meaning to the consultant's role [81]. The social dimensions of acceptance or rejection as well as credibility in the consultant-client relationship, therefore, have great significance. Acceptance enables the consultant entering the power structures of the client's company and gaining the legitimization to influence the processes of the client with the consulting project. Acceptance helps the consultant to achieve the appropriate level of authority. His role then changes from solely being a supplier to being an autonomous actor. An accepted social position increases the possibility that clients adopt the findings and analysis results of the consultant [39]. The matter of credibility is best understood in conjunction with the functions and roles the consultant is supposed to assume, since credibility pertains to specific sets of behaviors, interactions and circumstances. Consultants have different degrees of credibility in their various roles, relationships and situations. The manner of how the client attributes credibility to the consultant, and consequently how signification structure is created within the consulting system in that regard, is, therefore, dependent to the conscious or unconscious expectations towards the consultant, whether primarily providing information, diagnosing problems, applying specialized expertise, facilitating, solving problems or implementing solutions is in focus of the client's expectation [82].

As indicated above, signification structure of the consulting system is produced with creating meaning based on the client's expectations and the attribution of acceptance and credibility to the consultant. This production of significance is done by human action of communication. Giddens argued that communication involves the utilization of shared interpretative schemes, which are stocks of knowledge that human actors use to make sense of their communicative actions. This type of knowledge mediates the production and reproduction of signification [69] [83]. Clegg noted that "consulting is first and foremost a linguistic activity—a discursive practice through which realities are enacted" [84]. In the framework of the Structuration Theory communication can be regarded as cooperative practice referring to specific rule or resource sets that are produced jointly and reproduced through shared, recurrent social and economic interactions among individuals [69].

Cooperative practices are formed by shared purposive activities between the consultant and the client. This also requires the presence of consultation willingness of the client. The actual consulting service as the product is to be concretized while the consulting processes are carried out based on cooperation between consultant and client [17]. The social atmosphere between client and consultant forms the basis for effective communication. Communication plays an important role during the consulting process in the sense of integration, information gathering, transparency, debating and decision-making functions [85]. As there are many activities the consultant cannot carry out properly on his own if the client's employee is reluctant to collaborate, it is vital that a high level of client's involvement is given, possibly via allocated responsibility for certain tasks. This will promote client's identification with the results and his readiness for collaboration. To enable cooperative work, relationships among the client and the consultant are formed by signaling readiness to act and deliberate discursive action. The characteristic of agency included in the Structuration Theory also has implications for the analysis of cooperative work. An important implication is that cooperative work practices of the consultant can have significant effect to meet the client's unconscious needs for ontological security expressed on the unconscious level, which is inherent in the consulting processes due to the transactional and institutional uncertainty of consulting services. Collaborative work practices can help to maintain social identity of the client's employees, promote meaningful social interactions and develop self-esteem and psychological security. On the level of practical consciousness cooperative work provides rationalizations to the client and facilitates information sharing between client and consultant. At the discursive level, the cooperative practices promote both consultant's and client's capabilities to refine, discuss, and evaluate cooperative practices in order to involve them into the project outcome (compare to approach of Lyytinen and Ngwenyama [83]).

Communication as an interaction scheme of the Structuration Theory also focuses on knowledge creation and learning, both as two elementary components of most consulting projects. Even though projects have the character of a temporary system they have to be perceived as being embedded in a more durable set of contexts that survive the project and serve as knowledge and learning repositories. It needs to be emphasized that the clients and the consultants are knowledgeable and purposeful in their actions. They are capable to provide a rationale

for their actions through their reflexive monitoring of the project based interactions. It is assumed that consultant and client may influence the learning contexts of their project-based interactions without fully controlling these contexts. Thus, each learning context is a contested terrain in which reciprocal influence between consultant and client exists (compare to approach of DeFillippi and Arthur [86]).

6.3. Domination Exercised by Power: Actionability in Consulting

The Structuration Theory argues that the capability of an agent to draw on power resources is related to domination at the level of structure [69]. Giddens identified two types of resources of power: command over allocative resources (objects, goods and other material phenomena) and authoritative resources (the capability to organize and coordinate the activities of social actors).

Giddens highlighted the transformative capacity of human action, which may be a positive outcome, relational power or domination, involving reproduced relations of autonomy and dependence in social interaction that have negative connotations [69] [87]. Macintosh argued that power in the broader perception is the ability to get things done, while power in the narrow perception is simply domination. All social relations involve power in both perceptions, but the exercise of power does not occur in one direction only. Power can be exercised by both superiors and subordinates. He highlighted with discussing the “dialectic of control” that all social relations involve both autonomy and dependence. Normally, power flows smoothly and its effects remain widely unnoticed. However, conflicts are supposed to expose power. In that conjunction it is important to summarize the view on power with highlighting that power on the one hand works to control individual actions and to gain cooperation, but it also works on the other hand to free action [69] [87].

As a result of that, the domination structure for the consultant in the consulting project describes his capacity to act during the consulting process and, therefore, what influence he has in guiding the consulting project, identifying and determining the solution and outcome of the project, and, consequently, to what extent the consultant can impact the client organization. This playing field of the consultant is foremost determined by the consultant’s role, which outlines his potential for giving directives towards the client within the bounds of the consulting project, and, thus, the intensity of domination he obtains. This can also be described with consulting intensity. Within the boundaries of the consultant’s role, his domination potential is driven by his expertise of knowledge and methodical skills, his personality characterized by charisma and appearance, his assertiveness and convincibility. According to von Rosenstiel, the actual domination structure is concretized by the level of sanctioning potential the agent has. This can be the reward potential on the one hand, with honoring a desired behavior of loyalty. On the other hand, this also refers to the escalation potential of threatening somebody with punishment [88].

Based on that, the domination structure of the consultant during the consulting process is to be described as relatively weak on an initial view. The consultant does normally not obtain a formalized decision power, but acts as a “supporter” for a certain time-frame. Despite the fact that the domination of the consultant is relatively higher the higher the management level of “the buyer” in the client organization is, the domination of the consultant however remains in strong dependency to the domination of this buyer. Consequently, the domination structure is an important social facet that is to be developed during the consulting process based on the recursive practices of the consultant in interactions with the client. The consultant has to engage his expertise in knowledge and methodical skills in an appropriate way to build capacity to act. He steadily has to bring adequate personal skills to achieve a status on which he is able to convince and on which he can assert the matters of the consulting project within the terrain of the consulting project.

The domination structure of consulting projects is also characterized by the given authoritative and allocative resources of the client organization. Here, the client’s hierarchical structure and power bases play an important role. The consulting system is impacted by client’s political landscape. Here, the main players are the sponsor (who normally acts as supporter for the consulting project), the receiving managers as acceptors for the consulting outcome as well as other interested parties or constituencies with different agendas and with the potential of opposition. The political climate can change over time as the domination structure of the client organization matures through the created dynamics from the consulting project. The strengths of potential coalitions and ways to develop relationships to negotiate or arrange trade-offs to gain support or decrease opposition are essential for the domination structure [89].

Next to this, domination structure for the client-consultant relationship also has significance with regard to the

change impact to the allocative resources of the client organization. This concerns e.g. shifts of processual or institutional ownerships as an outcome of the consulting project. Hereby, power positions within the client organization can change as outcome of the consulting project and power relations are to be renegotiated, which comes along with production and transformation of discursive practices under conditions of novelty and ambiguity. Moreover, agents marginalized in their own organization may have the potential to exercise power discursively even when they do not have the apparent domination on the initial view. In the concrete consulting situation they can produce resistance with dispensing their expertise or personal engagement and, thus, limiting the effective implementation of the consulting outcome.

According to the Structuration Theory, power is inherent in structures and is applied on the interaction level between the agents. However, power is considered not to be simply oppressive or in the hands of elites and leaders [69]. Therefore, substantial power positions can also be held by client's employees on a lower level. As a result, power always needs to be incorporated in any analysis of social interactions between the client and the consultant. Power is not to be conceptualized as an unwanted effect or as an obstacle to change, but as a normal characteristic of the consulting system. Power-relationships are part and parcel of organizational life. It is particularly important to pay attention to power in situations of organizational change projects, when the re-allocation of resources is on the agenda [60] [90]. In Giddens Structuration Theory, power has, therefore, two different perspectives: the perspective of an action of the actor and the perspective of the structural aspect. Power is, then, the ability to make changes to behavior and control, or to create domination from an institutional perspective [69] [91].

But power positions have also relevancy in the context of consulting projects when the consulting system is concerned with micro-politic games, as production and transformation of discursive practices may shift power positions within the client organization. Moreover, client agents marginalized in their own organizations may have opportunities to try to exercise power discursively even when they do not have the apparent capacity in term of hierarchical authority, expert credentials, or economic resources to do so. To the extent that others accept their attempts, power relations may be shifted [32].

The consulting interactions can further-on be perceived as processes of negotiation and exchange. Exemplarily, the consultant in the role as initiator expresses recommendations about which the client can then decide whether and how they should be implemented. In this regard power is considered as the platform that determines what flows into the interactions and how it is adopted [30]. At first the buyer has the power to select an appropriate consultant and to assign him a respective role [92]. During the consulting project there is a high risk of power conflicts that arise on the fact that power is frequently associated with expertise and experience. Consequently, status claims exist as soon as multiple parties interact in the consulting system. Hereby, power can be expressed with setting directives or demonstrating resistance [32]. Apart from that, the consultant is generally assigned with a certain portion of personal power based on his engagement by the client for the consulting project. The power position of the consultant in dealing with the clients can base on referent and expert power. Referent power relies on personal characteristics of the consultant and is closely related to his professionalism and his role as archetype. Referent power by the consultant is frequently observed when there is already a very close relationship between consultant and certain parties of the client organization. Expert power is conferred when the client believes the consultant is knowledgeable and the client regards this knowledge to be valuable [93].

6.4. Legitimation and Sanctioning Consequences: Uncertainty in Consulting and the Urge of Control

Legitimation in the framework of the Structuration Theory can be practically interpreted as the level of norms, standards of morality, proper conduct and traditions that constitute organizational and social structures [94]. Bringing this dimension into the analysis of the consulting context, the fundamental portion of legitimation for consulting engagements is ascribed to the ultimate role of consultants as neutral instance within the organizational game. Due to the fact that consulting is a non-regulated business and is characterized as unbounded profession, consulting associations recommend their members to practice based on ethical guidelines and codes of conduct. These guidelines however have no legal binding for the consulting firms and cannot be enforced. Consequently, client firms have no guarantee that consulting firms comply with them. Monitoring a consulting firm's compliance with these principles is hardly possible. Codes of conduct at best encourage appropriate beha-

behavior, but there is no institutional guarantee against the possibility of misuse [24]. As a consequence, client firms face a significant degree of uncertainty as there are no institutional orientations to distinguish qualified from non-qualified consulting providers [6] [62] [95]. Moreover, in practice it is shown that large consultancies prefer to use their own, widely recognized brand for differentiation purposes. Consultancies are concerned that any kind of standard qualification in the consulting industry (e.g. industry-wide academic certification programs) would make individual consultants more mobile, why they would require higher effort to retain qualified personnel. This uncertainty problem is not controlled by a superior instance: as the consulting industry is not a traditional regulated profession, it has no widely accepted or obligatory ethical standards the consultants have to comply with [96].

Since questions on the legitimation of the consulting function lead to uncertainty towards the reliability of the consultant, the client may have a control demand about the consultant during the engagement. This has a sanctioning effect on the role of the consultant. The client as the holder of the relevant economic resources affected by the consulting project feels forced to gain transparency about consulting processes and sets short reporting intervals, since, at the end of the consulting engagement, the client organization faces its economic consequences [32]. The client is furthermore suggested to establish institutions to reduce uncertainty in that regard [97]. Those deficits are sometimes tried to be solved via detailed screening or with establishing a formal consulting governance by the client [98].

Therefore, uncertainty is seen as a critical barrier for creating consulting readiness on the client side, which is of vital importance for the success of the consulting engagement. Consulting readiness comprises readiness for cooperation and receiving criticism during the joint development of strategies and solutions in the analysis phase as well as respective readiness for adopting transformation results in the implementation phase [85]. Consequently, building an effective relationship with the client organization is the predominant driver for the success of the consulting project [39].

A further reason for the high level of uncertainty when engaging consultants originates also from the power position that the consultant usually gains within the client organization [79]. In particular, the consultant is assigned with legitimate power when he receives the mandate to reorganize departments or divisions with an amount of independence [50]. The power of the consultant is expressed by the possibilities for steering changes, as he can decide the way in which the analysis and the design of methodologies are applied, the manner in which the project is routed by setting priorities and the level of impact on decisions when preparing and communicating the analysis outcome [99]. This has increased relevancy when the consultant has been deeply integrated into the client organization and obtains a high level of acceptance. The consultant is then often awarded with an authority function within the client organization [39]. Moreover, the very nature of consulting often allows consultants to access confidential information of the client organizations. Hereby, they can sketch out and assess the client's competitive advantages, specific knowledge, sociopolitical constellations and financial data. All this implies sensitive information for the client organization. This information access makes the client vulnerable to opportunistic behavior of the consultant [24]. Therefore, the existing mistrust can substantially obstruct an efficient working relation [100].

As a consequence, the consultant's possibilities for opportunistic behavior create mistrust in the client's employees. There is substantial risk during the consultant engagement that the consultant's actions and decisions are detrimental to the client organization. The client is faced with the hazard of hidden intentions by the consultant, which could be revealed after the contracting phase when the consulting project is in progress [98]. This is in line with other typical agency problems, such as hidden actions [opportunistic behavior of the consultant] or hidden characteristics [inadequate expertise and capabilities of the consultant] [97]. Even more, studies have shown that clients regularly assume that consultants also pursue their own strategic goals during the engagement [101].

6.5. Summary: Consulting in the Dimensions of Structural Duality

Figure 2 outlines the capture of essential influencing factors for the quality of the consultant-client relationship based on the framework of the Structuration Theory. The structural elements of the consulting process as a social scheme cannot be perceived as isolated entities. They need to be analyzed in interrelated manner together with the types of interactions, as the execution of communication, power and sanction steadily reproduce these structures in the course of the consulting process. Furthermore, all structural properties of the consulting system

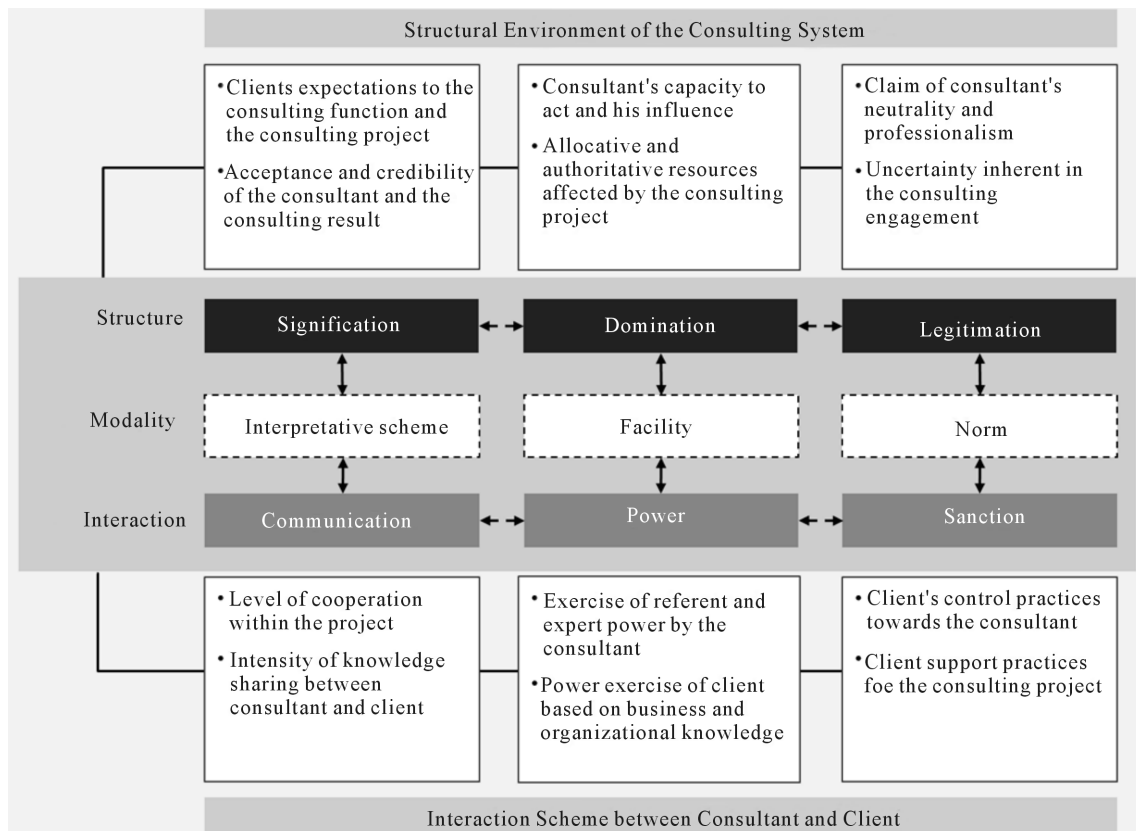


Figure 2. Consulting in the dimensions of structural duality.

are the medium and outcome of the contingently accomplished activities of actors involved in the consulting process. The structures like the client's expectations and acceptance, the consultant's capacity to act or inherent uncertainty are important features of any consulting situation. These can have both enabling and restricting effect on the interactions between the consultant and the client. Therefore, the interrelation of interactions between the consultant and the client [communication, power and sanction] and the structures determines how the quality of the consultant-client relationship can develop.

7. Conclusions and Reflections

With looking on the real long-term holdovers of consulting projects that rest in the client organizations, it is estimated that 80% of the consulting interventions from consultants do fail [102]. The high number of failed consulting projects, the evolved dissatisfaction of clients with consultants and the deficit of legitimization require the investigation of the effectiveness of the consulting service [103]. For that purpose, the reasons for failures in consulting engagements need to be determined. Scientists and practitioners particularly suggest the analysis of the consultant-client relationship for identifying advancements of effectiveness in consulting [104] [105]. With investigating the consultant-client relationship, it is risky to regard it as a sole input-output relation in the picture of a trivial machine, as a clear determination and prediction of the output in terms of the reaction and the response is not possible. It is also important to note that failures of consulting engagements cannot be fully attributed to the consultant. Instead, the consulting situation needs to be investigated on a holistic level.

Here, the Structuration Theory provides the potential to capture the consulting situation in a context of integrating the surrounding sphere. It infers the logic of interactions between the consultant and the client from the attendant organization and institutions with referring to the structural forces given in the consulting system that determine the actions of the consultant and the client. In the perspective of the Structuration Theory, the patterns of the relationship between the actors of consulting build the structural framework of the consulting system. The consultant-client relationship is constituted as a social system that develops in time and space through the inte-

ractions between consultant and client during the consulting engagement. The Structuration Theory regards the consultant and the client as role-taking and norm-fulfilling agents that act and communicate according to their images of what reality is. In doing so, they produce and reproduce structures of signification, domination and legitimation in a process of structuration.

The application of the Structuration Theory underlines the actual challenge of most consulting situations: the actual objective of many consulting projects is not to solely solve a distinct and isolated problem, but to initiate change and transition with all affected actors of the client organization in conjunction with that problem. This implies that structures have to be targeted that are reproduced by social practices of the client organization. The initiation of those social practices does however not follow any regularity or rationality and, therefore, does not enable generalizable predictability. Instead, social practices mainly base on individual interests. They also need to be analyzed in conjunction with power about resources (compare to approach of Hellmann in [52]).

Furthermore, the Structuration Theory balances the conception of the consultant and the client as the agents of consulting with the inherent structures. On the one hand, both the consultant and client are perceived as individual and social agents that have reflexive capabilities. This is important to capture the subjectivistic components of their behavior. On the other hand, the Structuration Theory also emphasizes the importance of determinism from the existing structures of the consulting system, which enables or restricts the behavior of the consultant and client. This comprehension enables incorporating different categories and dimensions that influence the consulting process with highlighting its social impact on both the behavior of the consultant and the client. A lot of existing research on the consultant-client relationship tends to concentrate either on the perspective of the consultant (e.g. [52] [57] [106]-[108]) or the client (e.g. [11] [48] [49]). In contrast to that, it is important to create a view on both with focusing on the interactions between them, as this can be regarded as the outcome of the prevalent structural set that is inherent in the consulting system. With applying the Structuration Theory in this research work it is argued that the client organization is not uniform. Contrary to that, the client organization represents a heterogeneous cluster of actors, interests and inclinations involved in multiple and varied ways in the consulting project [109].

Consequently, it is crucial to investigate how consultants and clients act and interact, and more specifically, why they act and interact in that way [30]. The actual output of the consulting system in terms of performance in achieving the goals of the project is determined by the structural set and by the way the agents of the consulting system adopting it as well as dealing with it.

The approach of the Structuration Theory provides an ontological framework for the study of the social actions of the consultant and the client and considers these actions as recurrent social practices with transformational capabilities. Moreover, it outlines the recursive interplay of social interactions within and across the involved client and consulting organizations. Structures of the consulting system, both in the broader sense and in the narrower sense, are viewed as “internal” to the action of the agents of the consulting project. Interactions between the consultant and the client are not conceptualized as isolated happenings or dyadic interrelations, but are considered as streams of interactions that are bound to their context. Furthermore, the consulting participants are seen as embedded in the social context of the consulting system, including the history of their previous interactions.

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Progress in the Development of Environmental Risk Assessment as a Tool for the Decision-Making Process

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Abstract

Environmental Risk Assessment (ERA) is a powerful technical and analytical set of instruments for analyzing adverse environmental impacts, and has found some application in supporting the decision-making process over the last two decades. In this paper, the progress of ERA, including history, types, approaches and methods, are introduced, and the current problems and development prospects of ERAs for decision-making processes are discussed.

Keywords

Environmental Risk Assessment, Progress, Types, Approaches, Methods, Decision-Making

1. Introduction

Environmental Risk Assessment (ERA) is a process that evaluates risks to environment caused by human activities and natural disasters, it also assesses the appropriate level of precaution and interrelated risk management measures to reduce and mitigate hazards, and their adverse impacts so as to achieve an acceptable risk level [1]. ERA as an important component and useful technical method of Environmental Impact Assessment (EIA), thus helps to evaluate, prevent and alleviate extremely adverse environmental impacts. In this way, it can provide scientific evidence for environmental decision-making, and therefore has been widely applied across the world over the past several decades [1] [2].

Much historical experience suggests that incorrect decision-making will cause adverse, long-term, and even irreversible environmental impacts [3]. For instance, the “Central Asia Planning” developed by the Union of Soviet Socialist Republics has caused serious coastline erosion and frequent “White Strom” disaster around

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Caspian Sea and Karakum Desert since 1954 [3]; In China, irreversible changes and serious sedimentation problems have frequently occurred in the main deep-water lanes of the Yangtze River, the effects of which were amplified by harbor construction and the shipping management measures since 1983 [4]. Therefore, consideration of extremely adverse impacts and developing the relevant ERAs in response to this will help support decision-making and the services derived from it. In that way, the ERA can play a more important role in avoiding and alleviating environmental risks that may derive from the process of decision-making. However, the adoption of ERA, as a formalized analytical process applied to environmental issues, and latterly as a policy tool to assist regulators in decision-making process (DMP), is a relatively recent development, when techniques broadly similar to the ERA of today were used in 1930s to set permissible occupational exposure limits for chemicals in the workplace[2] [5].

In this paper, the research progress of ERA, *i.e.*, development history, types, approaches and methods of ERA and its applications in DMP, are introduced and reviewed.

2. Progress of ERA

2.1. History of ERA

ERA has made great progress, and developed many approaches and methods over the past several decades. Although the formal assessments of environment risks from toxic substances to human health in ambient and occupational settings have been conducted since the 1930s, a systematic and overall quantitative approach to ERA can be traced to the work of US National Research Council (USNRC) in 1983 [6].

The 1980s and 1990s saw great strides in developing and improving tools to apply to risk assessment [7], *e.g.*, this includes low dose extrapolation model, physical and physico-chemical models and statistical models. The advent of computer-assisted modeling and data handling techniques had transformed the conduct of ERA in the 1980s and 1990s. As a technique, ERA has developed from human health risk assessment and has been subsequently extended to other environmental problems, including accident risk assessment, natural disaster risk assessment, ecological risk assessment and regional comprehensive risk assessment [5] [8].

With the development of decision analysis techniques, the application of ERA has widened since the late of 1980s to provide scientific evidence for environmental management [2] [5]. For example, risk evaluation based on Risk-Cost-Benefit (RCB) [1] [9] [10], Comparative Risk Assessment (CRA) based on the methods of Multi-Criteria Decision Analysis (MCDA), *e.g.*, Multi-Attribute Utilize Theory (MAUT), Analytic Hierarchy Process (AHP) and Outranking [11]-[14]. In a word, the use of ERA has developed from single types of risk assessment to regional comprehensive risk assessment, and recently in its widest application of supporting environmental DMP [8] [15].

2.2. Types of ERA

Integrating the basic concept of ERA from USEPA [1], the characters of different risk sources, or the different evaluating objects of ERA [16], and the different space scale of ERA [17], the main types of ERA were concluded as follows:

- (1) Traditional ERA, including health risk assessment, accident risk assessment, natural disaster risk assessment, and regional comprehensive risk assessment;
- (2) ERA for DMP, including all actions of ERAs involved in the process of DMP and supporting the selection and determination of preferred alternatives of DMP.

It is remarkable that the generalized ERA also includes ecological risk assessment, which was derived from initial human health risk assessment, but mainly focuses on the risks to ecosystems, excluding humans. However, this paper mainly discusses the adverse impacts on human health and relevant abiotic environment, in order to reflect the difference between the environmental risk and ecological risk. Thus the review on ecological risk assessment did not be involved in the next contexts, and would be took as another special type of risk assessment to be discussed in other papers.

2.3. Approaches and Methods of ERA

2.3.1. Traditional ERA

A) Approaches

(1) Health risk assessment

Health risk assessment is a type of ERA which originated in the USA, and has among all ERA the longest history and widest application around the world. In considering a conceptual framework for the identification and assessment of risks to human health, USNRC [18] created a process comprising the following four stages: hazard identification, exposure assessment, toxicity assessment, and risk characterization. This seminal contribution of USNRC has influenced the conduct of risk assessment world-wide.

USEPA proposed a potential approach (Figure 1) in 1992 [19] redrawn from the conceptual framework proposed by USNRC in 1983, which comprised the following three stages: problem formulation, problem analysis including exposure assessment and impacts analysis, and risk characterization and uncertainty identification. This approach has been widely suitable for human health risk assessment (or ecological risk assessment) associated with chemical and toxic substances pollution.

Subsequently, other organizations and countries, Health Council of the Netherland [20], World Health Organization (WHO) [21], and Australian and New Zealand [22], proposed similar approaches on the basis of USEPA scheme.

(2) Accident risk assessment

Accident risk assessment emphasizes the use of relevant mathematic models to calculate the risk (probability) and its corresponding consequence. United Kingdom Department of the Environment (UKDOE) proposed a common framework (Figure 2) in 1995 [23], which comprised the following six stages: hazard and consequence identification, probability and consequence estimation, risk estimation and evaluation, risk assessment, the proposal of risk management measures, and risk monitoring.

However, special processes of various accident risk assessment would differ in detail due to their different risk sources. The common approaches of various accident risk assessment were concluded in Table 1.

(3) Natural disaster risk assessment

Natural disaster risk assessment is a relatively recent type of ERA, which developed from the late of 1980s and mainly emphasized the analysis of the relationship between vulnerability to disaster and other hazards. The common approach of risk assessment for natural disaster (e.g. flood, seismic, typhoon, avalanche and so on) could be concluded as follows: historical data collection, disaster-inducing factors identification, the probability estimation of each disaster-inducing factor under different risk intensity, the vulnerability analysis of disaster-affected body, corresponding consequence estimation under different risk intensity, and risk evaluation and characterization [32] [33].

(4) Regional comprehensive risk assessment

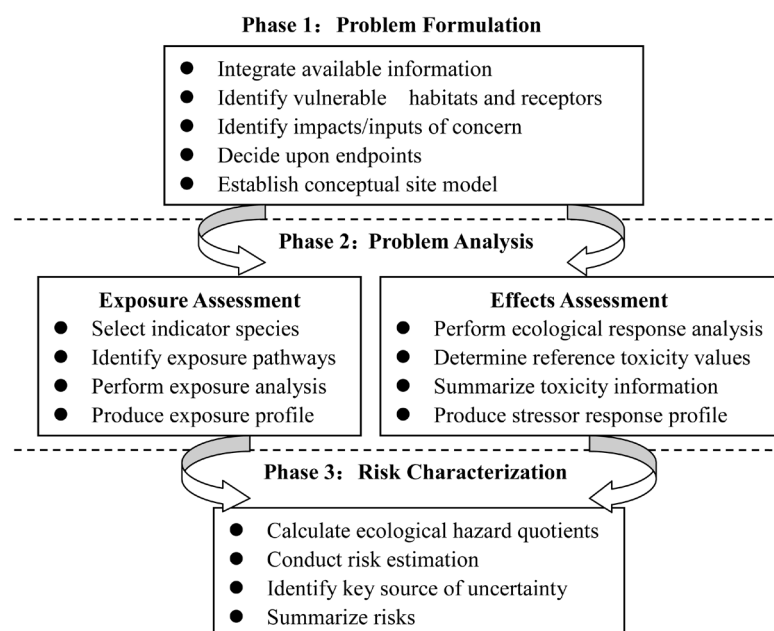


Figure 1. The three phases of healthy risk assessment [19].

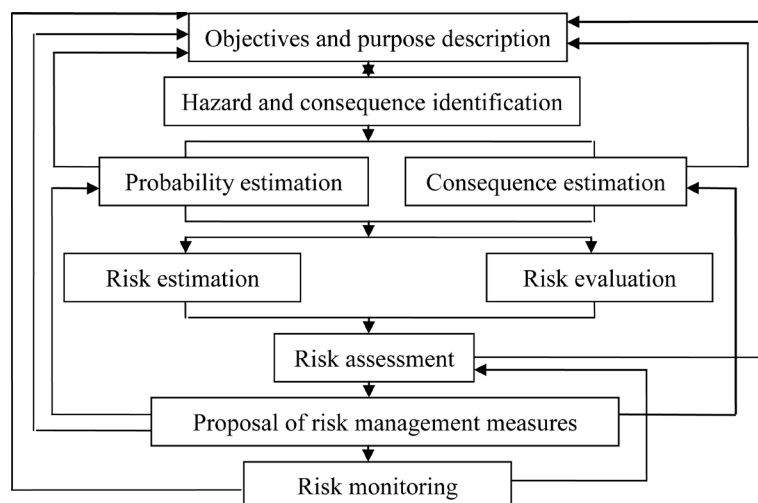


Figure 2. The framework for risk assessment and management of UK [23].

Table 1. The common approaches of various accident risk assessment.

Risk sources	Common approach
Nuclear accidents (The leakage of oil depots and natural gas)	Historical data analysis, risk identification and hazard analysis, probability estimation and impacts prediction, and the proposal of preventive actions and emergency plan [24]-[26]
Chemical and toxic substances (The leakage of chemical and toxic substances)	Pollution scope identification, physical and chemical analysis of sample, main pollutants identification, dose-response assessment, risk evaluation and characterizations [27] [28]
Marine accident and oil spills (Petrochemical industry accidents and other projects accidents on the sea)	Retrospective and status-quo assessment, risk source identification, predicted analysis including the probability and corresponding consequences, and risk evaluation and characterizations [29]-[31]

Because the development of regional comprehensive risk assessment started late, there has been relatively little research done in China or elsewhere. Regional comprehensive risk assessment emphasized the integration and ranking of different types of risks in each research region, and Yang and Xie [34] described its common approach (Figure 3) as follows: historical data collection, regional risk sources identification, probability estimation of signal risk type, impact estimation of signal risk type, risk assessment to single risk type, comprehensive assessment to types of regional risks and regional management and zoning. Similar approaches included other representative processes proposed by Calamari and Zhang [35], Xu and Liu [36] and others.

B) Methods

Some methods commonly used in traditional ERA are summarized as follows.

(1) Expert judgment

Expert judgment is a qualitative or semi-quantitative method, which has been used to develop risk identification, risk analysis and risk characterization through collecting experts' opinions, or their scores in situations where data are lacking. For example, expert judgment has been used to deal with the issue of inadequate data in the risk source identification of human health and contaminated environmental media [2] [14] [37]. USNRC [31] identified the risk causes of oil spills from vessels around Aleutian Islands by collecting historical information and experts' opinions. Moreover, expert judgment has also been applied to qualitatively evaluate the hazard indexes of natural disasters (e.g. seismic, typhoon) and the vulnerability indexes of any disaster-affected body when there is a lack of abundant data to estimate them [38].

(2) Retrospective and status-quo assessment

Retrospective and status-quo assessment includes some traditional methods e.g., *in-situ* investigation, statistical analysis and analogy analysis, which has been applied to identify and analyze risk source and their historical probability and impacts. These have also provided evidence for the prediction of risk trend (prediction im-

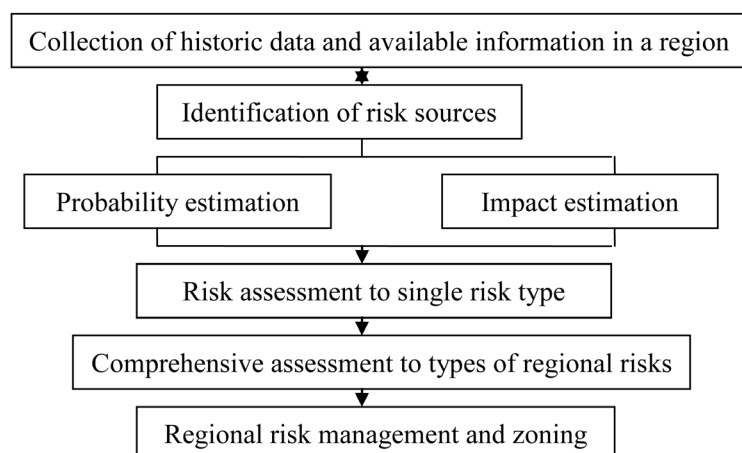


Figure 3. The framework for regional comprehensive environmental risk assessment [34].

plies the future) by collecting and analyzing historical information. For example, Van Drop *et al.* [39] and Merriker *et al.* [40] used retrospective and status-quo assessment to identify the possible causes of vessel accidents and estimate the probability of each cause by collecting and analyzing relevant historical data in San Francisco Bay and Washington State, respectively. Zhang *et al.* [41] collected historical data and used retrospective and status-quo assessment to analyze and conclude the cause and the average loss from typhoons in the southeast coastal area of China.

(3) Scenario analysis

Scenario analysis has been used to qualitatively or quantitatively identify and predict the potential risks including their risk probability and corresponding consequences when there is a change in their risk causes (factors). For example, Kepner *et al.* [42] used scenario analysis to define future scenarios in the form of land-use/land-cover grids, and examine their environmental impacts including relevant risks on surface-water conditions in San Pedro River, Mexico. Duinker and Greig [43] reviewed the development of scenario analysis, and discussed how to use scenario analysis to predict the risk impacts under the situation of climate change. USNRC [31] used scenario analysis to predict and analyze different risk sources of oil spills from vessels and the impacts of different oil spills under different types of vessels.

(4) Fault-event tree

Fault-event tree was mainly applied in accident risk assessment to identify and analyze risk causes, as well as estimate the probability and corresponding consequence of each risk through logistic inference. For example, IMO [10] described the event tree model of oil spills from vessels, and used this method to identify and conclude the main causes of oil spills from vessels. Zhao *et al.* [44] used fault tree analysis to find the key factors that would cause the leakage from an oil depot and propose some prevention measures. Zhang *et al.* [45] conducted the fault tree analysis model to analyze risk causes of oil spills from vessels, estimate the probability of each risk cause, and then summarized them to attain the total probability of oil spills from vessels.

(5) Mathematic models

Mathematic models have been widely applied to predict risk probability and analyze uncertainty and variability of relevant model permeates.

For health risk assessment, dose-response and exposure model, e.g. passion model, logistic model, low dose extrapolation model, time series, multiple regression model and so on, have been applied to estimate the hazard indexes of toxic and carcinogenic substances caused by contaminated water and other environmental medium. They have also been used to reflect relationships between the exposure probability and risks for both chronic and acute exposure [46]. Monte Carlo Simulation and Bayesian models have been used in dealing with uncertainty and variability problems involved in the parameters selection in different dose-response and exposure models [2] [48].

For accident risk assessment, the probability statistic model [48] has been applied to estimate directly risk probability by combining historic data with analogy analysis. Yan and Ma [49] used the fuzzy mathematic mod-

el to conduct multi-criteria system in risk assessment of oil spills from vessels, and applied subordinating degree function and expert judgment to estimate corresponding weights of each risk cause of oil spills.

For natural disaster risk assessment, some mathematic models such as “disaster loss-exceeding probability curve” [50], “entropy weigh method” [51], have been used semi-quantitatively to estimate the various hazard and vulnerability indexes of disasters, and describe relationships between hazard of disaster-inducing factors and a disaster-affected body.

(6) Risk matrix model

Risk matrix model is a popular format for presenting the qualitative or semi-quantitative risk analysis with columns corresponding to various levels of consequence and rows to different levels of likelihood. It has been used to characterize the risk levels of project accidents, natural disaster, and maritime accidents by combining with expert judgment, public involvements, and its relevant judgment criteria of risk frequency/probability and its corresponding consequences. For example, Lin [52] used a risk matrix model to semi-quantitatively evaluate and characterize the risk level of typhoons in Xiamen Bay. USNRC [31] introduced the basic model of risk matrix, and used it to characterize risk level of maritime accidents around Aleutian Island; Sun *et al.* [53] estimated the sensitive indexes and risk probability of oil spills, and then used risk matrix model to characterize regional risk level of oil spills in Bohai Bay.

(7) Comprehensive risk index method

Comprehensive risk index is a method that estimates regional comprehensive risk index (value) by distributing the weight for each risk factor and estimating their weighted mean on the basis of using the normalization method and expert judgment. Comprehensive risk index method combined with GIS has been widely applied to semi-quantitatively estimate the natural disaster indexes including hazard indexes, vulnerability indexes, defense capacity indexes and so on, to evaluate the integral risk level of natural disaster and develop relevant regional zoning of natural disaster [39] [54]. Moreover, Comprehensive risk index method has also been combined with Analytic Hierarchy Process (AHP) and expert judgment to qualitatively, or semi-quantitatively estimate signal type of risk index, or regional comprehensive risk index when there is lack of data to be quantified in a given research area [34] [54] [55].

(8) Fuzzy comprehensive assessment method

Fuzzy comprehensive assessment method has been applied to evaluate and characterize regional comprehensive risk level. This method is derived from the fuzzy mathematic model, the objectives of which are to integrate and consider all risk sources in a given research region. It is used to set up a set of factors, distribute the corresponding weights for risk factors to conduct a set of judgment, and then characterize the level of each risk factors and regional comprehensive risk, through establishing the subordinating degree function and estimating the weighted average. For example, Xue *et al.* [56] used fuzzy comprehensive risk assessment method to establish a model of regional comprehensive risk in the Tarim Basin, China. Sun *et al.* [51] used fuzzy comprehensive assessment method to identify the potential risk resources of oil spills, estimate the comprehensive risk value of oil spills in Bohai Bay, and identify which harbor has the highest risk value.

(9) Regional risk zoning model

The German Advisory Council on Global Change [58] firstly proposed “Regional risk zoning model” in 2000, which constituted the relevant grading criteria to divide regional risk into three grades including normal area, transitional area and prohibited area. However, this method has not been widely applied to characterize the regional comprehensive risk due to there being many criteria that are hard to quantify and judge in this model.

2.3.2. ERA for Decision-Making Process

A) Approaches

The procedure of ERA serviced for DMP could be divided into two different approaches by using two types of decision-making tools.

(1) The approaches of risk evaluation based on RCB

First is the approach put forward by US Presidential/Congressional Commission on Risk Assessment and Risk Management (PCCRARM) [9], which can be considered in six main steps: problem/objectives definitions; risk assessment; options formulations; decision-making according to the result of risk assessment (selection and determination of the managerial options); take actions; monitoring, evaluation and feedback. Moreover, this approach emphasized that stakeholder involvement should be integrated in to the overall DMP. Other representative approaches similar to this approach, included that proposed by USEPA [1], International Maritime Organi-

zation (IMO) [10], Ricci [46] and others. These approaches of risk evaluation based on RCB commonly emphasize using a quantitative economical method “Benefit-Cost Analysis” (BCA) as the main technical tool to support the selection and determination of any preferred managerial option which has the highest benefit and the lowest cost from risk perspective.

(2) The approaches of CRA based on the methods of MCDA

CRA has been most commonly applied in the area of environmental policy analysis [12] [58] [59]. Central to CRA is the construction of a two-dimensional decision matrix that contains project alternatives scores on various criteria [12]. A CRA is generally comprised of three components [58]: 1) problem list—determination of the set of environmental problems areas to be analyzed and compared; 2) criteria for evaluating problem—a set of analytical criteria to define what the participant thinks is important to measure, such as pollution level or other risks to human health, ecosystem, or quality of life; 3) ranking—a process that participants use to sort out data and draw conclusions about the relative severity of the problems or their sub-components.

Although CRA lacks a structured method to identify an optimal project alternative, the MCDA methods do provide a systematic and complementary way for CRA to integrate risk levels, uncertainty and valuation [12]. Thus, CRA based on the methods of MCDA, has been a prevailing methodology for environmental decision-making [8] [12]. Linkov and Ramadan [59] proposed this approach in the following **Figure 4**. This approach emphasized on that the DMP process not only includes the integration of models and techniques of environmental (risk) assessment and decision analysis, but also includes the interaction among policy makers, scientists and stakeholders.

Similar approaches included other representative processes proposed by Khadam and Kaluarachchi [11], Linkov *et al.* [12], USACE [13], Topuz [14], Department of Energy (DOE) [60]. These approaches consider multiple criteria including economical, ecological, environmental, social and other factors in decision-making options and comparing risk related with different options based on MCDA methods, *i.e.*, MAUT, AHP and Out-ranking, to determine the optimal managerial option from risk perspective.

B) Methods

Some methods commonly used in ERA for DMP are summarized as follows.

(1) Benefit-Cost Analysis

BCA is a central method to RCB, which has been used to help formulate risk management policies and priorities and identify risk management goals that maximize net benefits across various levels of protection. For example, Power and McCarty [61] applied BCA to analyze the differences between various managerial options of risk reduction. Finney [62] used BCA to monetize the impacts of natural disaster on infrastructure and ecological value, and guide the risk planning and management. Ricci [46] used a dose-response and exposure model to evaluate the human health risk of carcinogens, and applied BCA to select the optimal managerial option for preventing the adverse impacts of carcinogens.

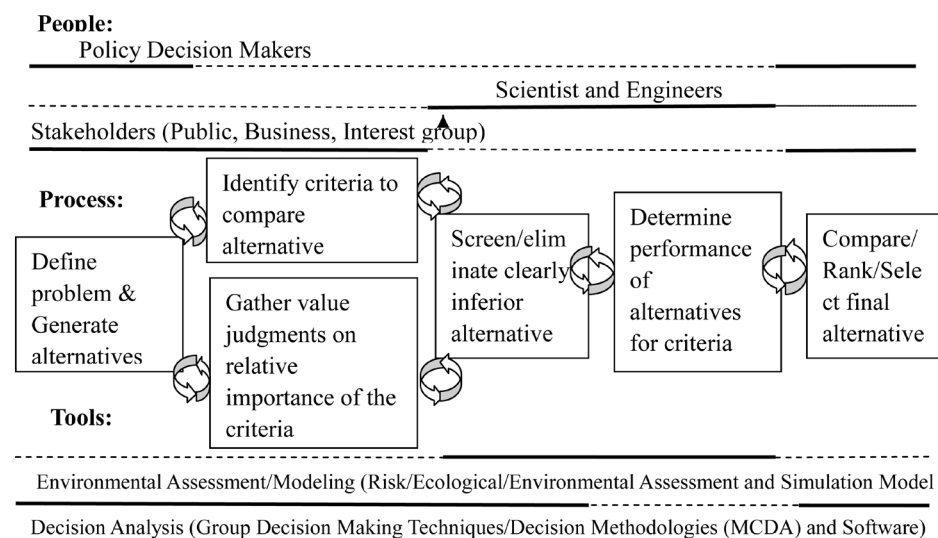


Figure 4. A potential approach for DMP based on CRA and MCDA [59].

(2) Decision-tree analysis

Decision-tree analysis has been used to predictably describe various potential environmental risks caused by different alternatives of decision-making, and estimate and compare their expected risk value to select the preferred alternative of decision-making from an environmental risk perspective. For example, Ricci [46] applied decision-tree analysis and RCB to select the optimal managerial option for preventing exposure to toxic substances from a human health risk perspective. Linkov and Kiker [63] used decision-tree analysis to assess multi-criteria risk (e.g. economic risk, environmental and ecological risk, and social risk) in an artificial marine ecosystem.

(3) MCDA methods

The MCDA includes methods of MAUT, AHP and Outranking.

1) MAUT

MAUT is a method to express overall performance of an alternative in a single, non-monetary number representing the utility of that alternative, which relies on the assumptions that the decision-maker is rational [12]. MAUT, for example, has been used in risk management of a radioactive site [64] and has also been utilized in the superfund cleanup process [65]. Wakeman [66] used the simple MAUT rating technique to analyze alternatives for degrading contaminated site in Montana. MAUT-based methods have also been applied to compare current and alternative water control plans in the Missouri River from a risk perspective [67].

2) AHP

The goal of AHP is to select the alternative that results in the greatest value of the objective function [59]. In AHP model, criteria weights and scores are based on pair-wise comparisons of criteria and alternatives, respectively [12]. For example, Apostolakis and his colleagues [68] developed AHP combined with risk assessment techniques to integrate the results of advanced impact evaluation techniques with stakeholder preferences. Sorvari and Seppälä [37] used AHP to identify the risk sources in a contaminated site and weight them by expert judgment to provide evidences for selecting the optimal managerial options. Chen *et al.* [69] use a redrawn AHP model—ANP model to identify the optimal allocation of an airport from the perspective of natural, social and building risk.

3) Outranking

Outranking is based on the principle that one alternative may have a degree of dominance over another [59]. Dominance occurs when one option performs better than another on at least one criterion, and no worse than other criteria [59]. For example, Ganoulis [70] used outranking to determine the optimal options of waste water recycling and risk management in the Mediterranean. Klauer *et al.* [71] applied outranking based on GIS to identify the risk source for the Rhine River and select optimal options for risk management.

2.4. Summary

The nature of ERA has been increasing mature developing and has formed a relatively integrated methodology since the 1930s. It has developed from single type of risk assessment, *i.e.*, health risk assessment, accident risk assessment, and natural disaster risk assessment, to a more regional comprehensive risk type of assessment. More recently, there has been a development of relevant ERAs to avoid and alleviate environmental risks derived from DMP, and support the selection of preferred alternatives. It has been a hot issue of ERA research internationally since the late of 1980s.

The approaches to ERA can vary in detail depending on their different evaluation objectives and space scales. The approaches of ERA processes for traditional ERAs (*i.e.*, health risk assessment, accidents risk assessment, natural disaster risk assessment and regional comprehensive risk assessments) and ERA for DMP (*i.e.*, risk evaluation based on RCB and CRA based on the methods of MCDA) were summarized in Table 2. The traditional ERA can be summarized by four steps. The processes of using ERA for decision-making are, however, relatively complicated because the emphasis is on combining the results of traditional ERA with decision analysis tools to provide scientific evidence for environmental management, which can be summarized in five steps (Table 2).

Different types of ERA have applied different methods. Most of the methods are summarized in Table 3. However, some methods could be used in several different types of ERA. For example, retrospective and status-quo assessment could be used in accident risk assessment, natural disaster risk assessment and regional comprehensive risk assessment. Expert judgment can be applied in any type of ERA when there is lack of data to develop sufficient quantitative information.

Table 2. Summarizations of ERA approaches.

Various types of ERAs	Elements of ERAs process	Summarization
Traditional ERAs	Health risk assessment	Analyzing the relationships between the dose of hazardous/toxic substance and the response of human health
	Accidents risk assessment	Using some mathematic models to estimate the risk probability and its corresponding consequence
	Natural disaster risk assessment	Analyzing the relationship between vulnerability to disaster and other hazards
	Regional comprehensive risk assessments	Integrating and ranking of different types of environmental risks in a given research region
ERA for DMP	Risk evaluation based on RCB	Using a quantitative economical method “BCA” as the main technical tool to support the selection and determination of any preferred managerial option from risk perspective.
	CRA based on the methods of MCDA	Considering multiple criteria including economical, ecological, environmental, social and other factors in decision-making options and comparing risk related with different options based on MCDA methods to determine the optimal managerial option from risk perspective.

Table 3. The main methods for different types of ERA.

The type of ERA	Main Methods
Health risk assessment	Dose-response and exposure model (e.g. passion model, logistic model, time series, multi-regression model and so on), expert judgment, Monte Carlo Simulation, and Bayesian model
Accident risk assessment	Retrospective and status-quo assessment, scenario analysis, expert judgment, fault-event tree, probability statistic model, fuzzy mathematic model, and risk matrix model
Natural disaster risk assessment	Retrospective and status-quo assessment, disaster loss-exceeding probability curve”, “entropy weigh” method, expert judgment, comprehensive risk index method, and risk matrix model
Regional comprehensive risk assessment	Except for methods for above three types of ERA, comprehensive risk index method, fuzzy comprehensive assessment method, expert judgment and regional risk zoning model were also commonly used
ERA for decision-making processes	BCA, Decision-tree analysis, MCDA including MAUT, AHP, and Outranking

3. Discussion/Conclusion

3.1. Problems in ERAs

Although the form and application of ERA has made great progress and there have been many new approaches and methods developed over past decades, some problems still exist in the current development of ERA. The main problems are as follows:

(1) Most applications of traditional ERA focused on project level. For example, all health risk assessments focused on the leakage of hazardous or toxic substances, and maritime accidents. Some applications of ERA focused on natural disaster risk assessment and regional comprehensive risk assessment. Although traditional ERA is an important support tool to provide scientific evidence for risk management, it only focuses on providing some technical procedure and corresponding methods for risk analysis and evaluation which are difficult to closely connect with DMP, and directly support and impact DMP and their final results [15].

(2) Many techniques of decision analysis (e.g. BCA, Decision-tree analysis, MCDA) have been developed for integrating the results of ERA into DMP to support the selection of optimal options for environmental management. However, most of present researches still focused on sectoral (managerial) DMP. There is no systematic research and interrelated application in China or internationally on the approaches and methods of ERA in strategic decision-making (SDM) processes.

(3) SDM can be viewed as a special kind of decision-making under “Long-term, Regionality, Integrality and Uncertainty” [72], and is much higher than a project or sectoral (managerial) decision-making that is located at the end of SDM process [73]. Therefore, all ERAs for project or sectoral decision-making are passive-active processes [8]. The predictability of adverse environmental consequences generally becomes weaker at strategic levels, than at the project or sectoral decision-making level, and complexity increases in terms of the numbers of actors involved in the decision [74]. Thus, most of approaches and methods of current ERAs could not avoid the environmental risk from the source of SDM processes and were unable to greatly impact the initial strategic arrangement and adequately predict the cumulative risk impacts of SDM.

3.2. Prospect

At present, it is accepted that the mistakes and environmental risk introduced by SDM process may lead to more significant and irreversible losses to society and the ecological environment than project or sectoral DMP. It is necessary to develop relevant approach and methodologies of ERAs for SDM to avoid the mistakes in SDM process.

Moreover, there is evidence that both pre-structured and pro-active EIA and EIA-based Strategic Environmental Assessment (SEA) are actually effective in improving decision making in terms of a better consideration of the environment consequence [75]. Furthermore, many practices suggest the assessment effect would be better if there was an inclusion of intervention time of SEA into the processes of decision-making at an early stage [76]. Thus, formal ERA (an important component of EIA) needs to be introduced as a pro-active instrument for addressing adverse environmental consequences before practical action of SDM.

From the above, there is an urgent need to propose potential approaches and methodological systems of ERA for SDM processes in order to intervene ERA into the overall process of SDM, and avoid environmental risk from the source of SDM. This is likely to be a future trend in the development and main objectives of ERA, and it should be of great significance for promoting sustainability of natural-social-economic systems.

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Determinant Factors in the Internationalization of Knowledge-Intensive Services in a Peripheral Area

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Abstract

The objective of this study is to learn some of the determinant factors in the internationalization of knowledge-intensive services in a peripheral zone in accordance with the Eclectic Paradigm [1] [2]. The study will focus on Andalusia in Southern Spain. In the Andalusian region, there are no official data on internationalized companies. We have therefore conducted a survey of 256 service internationalized companies within the region. The results show that the ownership or specific advantages considered by the businesses themselves is the quality of service, training of employees, leadership and management ability, innovation, technology and the image that customers have of the company. Regarding the advantages of locating abroad that are believed to be the most important, those companies that engage in foreign investment highlight customer' follow-up and look for new customers. As well, they greatly value those factors related to the destination market: size, growth and access to the market as well as other markets.

Keywords

Services, Exports, Foreign Direct Investment, Ownership Advantages and Location Advantages

1. Introduction

One of the most evident facts in developed societies is the consolidation of service economies. With the passage of time, especially during the second half of the twentieth century, agriculture and manufacturing have been losing importance in terms of the composition of employment and in value added in favor of the tertiary sector. Economic growth has coincided with the process of outsourcing of economies, thus this structural change has been coupled with a growing interdependence between all productive activities.

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In recent years, the service sector has experienced a boost due to certain factors such as the emergence of new technologies of information and communication (ICT) or the process of deregulation in some industries, and these have led to increased national and international competition and have encouraged the creation of companies in this sector. In addition, the strategies of some companies to outsource/off-shore tertiary activities have encouraged the development of business services and the internationalization of same. Thus, both production and consumption in advanced economies have been transferred from physical goods to services and, in particular, to those services related to information, converting this sector into a key driver for building competitiveness, employment and economic growth.

The service industry has become an important area of research in recent years. There are at least four reasons for the interest in this sector. Firstly, services account for an increasing share of output and employment in developed economies. Secondly, cross-border services are a key factor in reducing or even eliminating current account deficits in these economies. Thirdly, the business of providing services has grown dramatically in recent years within the general trend of economic globalization, making higher economic growth possible in those countries and regions that are participating in it. Finally, insufficient knowledge about the internationalization of the service sector justifies its study.

Among the various services, knowledge-intensive services (KIS), meaning those activities requiring a substantial base of human and technological capital, are increasingly regarded as crucial to the development of regional innovation systems [3] and to boost regional economic growth in industrialized countries. Along these lines, KIS act as users, creators and propagators of innovations, both technological and non-technological, playing a major role in the creation and dissemination of organizational, institutional and social knowledge, and generating positive externalities through the transfer and creation of useful innovations for other economic agents [4] [5]. Thus, the most recent theoretical and empirical analyses being carried out at an international level show that the various forms of feedback that result from knowledge-intensive services are among the causes of internationalization.

Some recent studies have shown how innovation rates are significantly higher in countries where there exists a wide range of advanced services compared to production. Furthermore, although it is possible to argue that technological advances like the Internet can help make up for deficiencies between regions, the fact is that, in most cases, international trade in advanced services is difficult given the need for face to face contact for the transmission of knowledge, and thus one of the most important ways that advanced services may be internationalized is by foreign direct investment.

Despite finding ourselves immersed in a global economy, innovation is in many ways an essentially regional phenomenon where services, especially those known as knowledge-intensive services, have acquired a central role through their ability to transmit knowledge, especially of the tacit type.

Given this context, this paper will try to understand the determinant factors in the internationalization of knowledge-intensive services in a peripheral region, Southern Spain. The paper is organized as follows: After this introduction, the second section will review the literature with regards to the internationalization of services, which has served as the basis for the empirical study, and the case of knowledge-intensive services will be alluded to. The third section is devoted to the methodology used, which is based on a survey of internationalized firms, and the fourth to the empirical study and results. The paper ends with some conclusions.

The chosen territory is Andalusia, a peripheral region located in Southern Spain. This area is characterized by a total population of 8,424,102 inhabitants as in 1 January 2011, representing 17.85 percent of the Spanish population. The level of GDP per capita in 2010 was 75.5 percent of the Spanish average, the second lowest of the 17 regions in the country [6]. However, expenditure on research and development compared to the regional GDP was 1.20 percent, the fourth highest after Madrid, the Basque Country and Catalonia. Regarding the process of internationalization, exports account for 10.05 percent of the Spanish total, while Andalusia's contribution to Spain's total foreign investment only amounts to 2.43 percent of the total, according to information from the Ministry of the Economy and Competitiveness [7] [8].

2. Theoretical Contributions

The purpose of this section is to measure to what extent knowledge-intensive Andalusian companies have conducted their internationalization process according to the Eclectic Theory proposed by Dunning [1] [2].

The traditional forms of internationalization of the company are: exports, direct investment and licensing of

production to foreign firms. Dunning considers that for a company to become internationalized through these pathways it must meet certain conditions, which are presented in **Table 1**.

The firm must possess ownership advantages—from now on also known as specific advantages or competitive advantages—over its competitors in the foreign country and even with respect to its domestic competitors. These advantages are associated with the company's intangible assets such as advanced technology, economies of scale, improved knowledge of marketing techniques and distribution... In order for the advantages to have an influence, they must remain exclusively in the company for a long enough period of time.

The company must have internalization advantages in order to be able to internationalize through exports or foreign direct investment. The first condition is not sufficient but it is necessary that the company has the desire and the capacity to internalize the particular advantage. This will be beneficial to the extent that it reduces market transaction costs.

If the company decides to invest in a particular country, it must offer location advantages over the country of origin. These advantages are not only associated with the costs and the availability of factors of production or the market, but also the particularities of the institutional system established in the country receiving the investment (tax system, labor regulations, degree of trade restriction, supranational integration areas, etc.).

These advantages are configured as the “OLI Paradigm” which links the decision to invest abroad to the characteristics of the company, the sector involved and the country that receives the investment. Each one of the concepts integrated into the “OLI Paradigm” includes different proposed theories about the causes that motivate foreign direct investment: 1) Specific or ownership advantages: Theory of industrial organization [9]-[15]; 2) Advantages of internalization: Theory of transaction costs [16]-[29]; 3) Advantages of location: Theory of location [30]-[37].

These theoretical and empirical studies have been fundamentally focused on industry, while those studies looking at the tertiary sector have been rather scarce. However, in recent decades, with the rise of trade in services, studies on the sector have begun proliferating [38]-[43], although the total number of studies is still limited. This justifies the continuing development of research on this sector in order to get a better understanding of the internationalization of services and, especially, knowledge-intensive services.

According to [44] and [45], the Eclectic Theory [1] may be applicable to service companies. However, other researchers question such applicability [46] [47] and claim the need to develop new theories specifically for the internationalization of services [48]. Thus, there other recent approaches that are applicable to the services sector and, in particular, to knowledge-intensive services, which we refer to below. *The network model of internationalization* suggests that this transnational process is a function of relationships of the company with its business and social network [49]. They consider that the involvement of businesses in networks of cooperation provides access to resources, information, customers and ideas for products or services that turn out to be more important for the internationalization process than their specific advantages. For its part, *The knowledge-based theory of the firm* is based on the nature of the skills and knowledge of the company and suggests that the transfer of these across borders is more efficiently performed by wholly owned subsidiaries, arguing that companies are more efficient in said transfers than markets [50]. The focus of *International Entrepreneurship* seeks to explain the internationalization of companies that are born global or become international at a time close to their inception [51] and in which the entrepreneurs, their characteristics, personal goals and experience have a crucial impact on the development of the company. Finally, the *Theory of resources and capabilities* shows how competitive advantages are generated by a set of key resources of the company [52]-[54] and is based on the assumption that there exists a heterogeneity among companies that can lead to them having different results (see [55]).

Table 1. Choice of the form of internationalization.

		Advantages		
		Ownership advantages	Internalization advantages	Location advantages
Ways to internationalize	Foreign investment	YES	YES	YES
	Exports	YES	YES	NO
	Licencing	YES	NO	NO

Source: Dunning, J.H. (1988, p. 28).

In this paper, based on the OLI Paradigm of Dunning [1], we try to learn about some of the advantages of ownership and of location for knowledge-intensive companies located in a peripheral region (Andalusia, Spain), without making reference to the advantages of internalization. Some of the specific advantages are shown in the **Table 2** and some of the advantages of location are specified in the **Table 3**.

Finally, it should be made clear that the economic literature has established services as activities different from goods, and that they have been characterized as being intangible, perishable, and their consumption usually occurs simultaneously with their production [56] etc. This last feature has tempered the ability to internationalize these activities to the extent that their production and consumption tend to occur not only at the same time, but also at the same place. In this way, the inseparability between producer and consumer has justified, traditionally, the existence of foreign direct investment as a method of international expansion of services in light of the impossibility of their being used for export. Thus, *a priori*, the form of internationalization of services is intimately linked to their own nature. Along these lines, there have been numerous studies that have tried to show the characteristics of different services and then tried to relate them with the forms of international supply [44] [57]–[66]. Recently, however, the emergence of new information technologies has allowed for the separation of the process of production and the consumption of services, which has encouraged exports in many of the activities in this sector that previously required the installation of an overseas branch.

3. Methodology

The methodology used to learn some of the advantages of ownership and location of knowledge-intensive companies in Southern Spain is a survey of 256 service companies which carry out operations of internationalization (See **Appendix**). This survey is part of a wider one in which tourism enterprises have also been studied as a contraposition to the former by the type of traditional services that the latter represent.

3.1. The Study Population

The sample universe consists of Andalusian companies included within the branches of activity of the National Classification of Economic Activities (CNAE) 2009 shown below, according to the classification of Eurostat. We wish to highlight that we have removed financial services from this classification, given the regional level of the companies under study and the fact that Spanish financial companies are mostly based outside of Andalusia. We feel that their inclusion could distort the results of the analysis when making comparative studies at a national level. Therefore, we have considered the following knowledge-intensive activities:

Knowledge-intensive high-tech services: Telecommunications (61); Programming, consulting and other activities related to computer science (62); Research and development (72).

Table 2. Chart of ownership advantages.

Size
Intangible assets
• Technology
• Innovation
• Brand
• Human Capital
• Image
• Organizational methods
Financing
Competitiveness
• Prices
• Productivity
• Production costs
• Quality

Source: The Authors.

Table 3. Location advantages of foreign direct investment.

Cultural and historical context

- Language
- Quality of life in the country
- Corporate culture
- Historical relations between countries
- Social awareness of the host country before the appearance of foreign investors

Availability of resources (basic and advanced)

- Availability of physical resources
 - Raw materials
 - Geographical location
 - Size of the country
 - Climate
 - Coastal
 - Natural sites
- Availability of labor
- Infrastructure
- Technological resources

Market characteristics

- Market size
- Growth of market
- Market access

Economic and political system

- Economic stability
- Political stability

Economic policy

- Trade barriers
- Exchange rates
- Integration of supranational economic areas
- Fiscal policy
- Labor market
 - Labor costs
 - Qualifications of workers
 - Productivity

Source: The Authors.

Knowledge-intensive market services: Maritime transport and inland waterway (50); Air transport (51); Real estate (68); Rental and leasing activities (77); Legal and Accounting services (69); Head office activities; management consultancy (70); Architectural and engineering; technical testing and analysis (71); Advertising and market research (73); Other professional activities, scientific and technical (74); Employment-related activities (78); Security and investigation activities (80); Office administrative activities and other ancillary business activities (82); Information Services (63).

Other knowledge-intensive services: Education (85); Health activities (86); Motion picture, video and television, sound recording and music publishing (59); Programming and broadcasting activities for radio and television (60); Creative, artistic and entertainment activities (90); Libraries, archives, museums and other cultural activities (91).

3.2. Areas of the Survey

- Population area: Internationalized companies corresponding to the branches of activity for the aforementioned industries.
- Territorial or geographical area: Internationalized companies who perform their productive work in Andalusia.
- Time frame: The survey was conducted in the months of April, May, June and July 2011.

3.3. Units of Inquiry

The set of units forming the sample are Andalusian internationalized firms of the branches of interest previously defined. To identify companies that meet the requirements of the sample selection, and to make the selection, various databases were used such as ICEX (-Instituto Español de Comercio Exterior-Spanish Institute for Foreign Trade) [67], Extenda (Agencia Andaluza de Promoción Exterior-External Trade Promotion Agency of Andalusia) [68], and the databases of the Chambers of Commerce [69], eInforma [70] and Axesor [71].

The companies that appear in these databases are there for having carried out some internationalization activity. The companies are broken down by branches of activity, also providing information about location: name, address, telephone number, contact person, etc.

3.4. Sampling Method

A stratified sampling is performed with proportional allocation, taking two strata, one for knowledge-intensive companies and the other for the tourism industry (codes 55, 56 and 79).

3.5. Sample Selection

The selection of the sample of internationalized firms is made by means of a stratification process from which the final sample size is determined. Stratification divides the population into subgroups or strata whose elements are homogeneous with each other, in order to carry out separate selections in each of them. Its purpose is to control the representativeness of the sample and determine, based on the stratum, the number of sampling units in each of them.

3.6. Sample Size and Sampling Methods

In order to carry out field work on service internationalized companies in Andalusia, it is necessary to extract a sample from the population universe of companies. According to the data of INE (based on the Central Directory of Companies—Directorio Central de Empresas—(DIRCE), [72] in Andalusia in the year 2010, there were a total of 173,434 companies distributed as follows by activity (See [Table 4](#)).

The official sources do not publish data on the number of internationalized companies in Andalusia in the branches of interest. To determine the sample size, the level of dispersion of the responses must be specified. Since the exact percentage of companies engaged in foreign activities is unknown, we assume the most unfavorable dispersion, that in which P and Q are equal to 0.5, *i.e.* the variance is maximized. This does not imply a large increase in the sample size and is the most utilized option in practice. A sample size of 386 is estimated, with a confidence level of 95 percent and a maximum permissible error of 0.05, distributed by proportional allocation. The sample used is a stratified random sampling, where the size of the strata is (See [Table 5](#)):

For the selection of the sample a random strata method was employed. Within each stratum, a number is assigned to each firm. By generating random numbers, the companies to be surveyed are selected. In the cases in which it was impossible to make contact with the selected companies, either due to a lack of response or the refusal to participate, other random numbers were generated and so on until the sample size was reached.

Table 4. Target population.

Companies by code number CNAE-2009 in Andalusia in 2010	Number of companies
50 Maritime and inland waterways	50
51 Air transportation	22
55 Accommodation services	2956
56 Food and beverage services	45,233
59 Motion picture, video and television program production, sound recording and music publishing activities	708
60 Programming and broadcasting on radio and television	389
61 Telecommunications	588
62 Computer programming, consultancy and other activities related to computers	1925
63 Information Services	586
68 Real estate activities	16,251
69 Legal and accounting	25,997
70 Activities of head offices, activities of business management consulting	1498
71 Architectural and engineering; technical testing and analysis	19,620
72 Scientific research and development	2525
73 Advertising and market research	3705
74 Other professional, scientific and technical activities	4709
77 Rental activities	4425
78 Employment-related activities	427
79 Activities of travel agencies, tour operators, tour operator reservation service and related activities	2005
80 Security and investigation activities	452
82 Office administrative, office and ancillary firms	8364
85 Education	10,748
86 Health activities	17,274
90 Creative, arts and entertainment	2676
91 Libraries, archives, museums and other cultural activities	301
Total	173,434

Source: The Authors.

Table 5. Strata sizes (number of companies).

Tourist internationalized companies	130
Remainder of the internationalized companies	256
Total	386

The sample sizes of the strata range are between 90% and 95% confidence. Maximum permissible errors of less than 8%

Source: The Authors.

3.7. Description of the Survey

The questionnaire is divided into eight blocks of information: Block 1: General information about the company; Block 2: International markets; Block 3: Competitive advantages; Block 4: Location advantages; Block 5: Barriers; Block 6: Assistance; Block 7: New technologies; Block 8: Innovation.

The main objective of analysis in our study is to learn the determinant factors in the internationalization process, which are centered in Blocks 3 and 4 of the survey and the general aspects of the internationalization process in Blocks 1 and 2.

3.8. Fieldwork

Data collection was carried out by scheduling meetings with entrepreneurs, management personnel or those in charge of their export departments. A survey team distributed in the Andalusian territory was used. They were responsible for scheduling meetings with the representatives of the target companies for a later visit in which the project was presented and the survey carried out.

4. Results

4.1. Internationalized Knowledge-Intensive Services Companies by Area of Activity

The internationalization process that the tertiary sector of the regional economy is involved in exhibits an unequal participation depending on the type of product offered on the international market (**Table 6**). First, we highlight Knowledge-intensive market services, which account for more than 60 percent of the companies analyzed. Among these are businesses linked to the technical services of architecture and engineering, which have a higher inclusion rate with a total share of 12.5 percent. In the same category, but with a somewhat lower relative weight, are those that provide consulting and business management services, which total more than 26 entities or 10.2 percent. Other representative activities included in this aggregate are real estate and other professional, scientific and technical activities, with a share of 7.8 and 9.8 percent, respectively. However, a lower weight is observed for those more capital intensive activities such as air transport (1.2 percent), and for other simpler ones such as office activities, auxiliary businesses and those related with employment.

In the category of other knowledge-intensive services, there are 65 companies out of the total number of respondents, representing 25.4 percent. In this group, those that produce educational services are in the majority with more than 30, having a share of 12.1 percent. These organizations offer a wide range of training products ranging from teaching Spanish to the completion of a Master in business management or emergency assistance. In most cases, the products are offered through a platform located in some Andalusian province which the foreign consumer accesses, acquiring the knowledge and achieving the training online. Among those Andalusian other knowledge-intensive services companies are also included those that produce film, video and television programming, sound recording and music publishing activities and those dedicated to programming and broadcasting of radio and television. Together, they account for 9.8 percent of the total.

Companies that offer more sophisticated knowledge-intensive services requiring a high level of human capital, account for 14.1 percent of the total, representing 36 respondents. Among these, equal prominence is observed for those involved in the field of telecommunications, which produce integrated communications systems, and those that focus on development of programming, consulting and other activities related to computer science. In turn, those that offer services of research and development only represent 3.9 percent.

4.2. Mode of Internationalization of Businesses

The internationalization of services, according to [73], is natural part of the evolutionary development of an open market economy. As we have previously shown, the methods of internationalization of service firms are strongly determined by their very nature and characteristics.

The main channel through which firms providing knowledge-intensive services are internationalized (**Table 7**) is via exports, with 21.5 percent of the cases giving a very high importance to exports and 19.1 percent a high importance. By contrast, the other channels such as licensing, joint ventures, franchises... are given no importance in more than 85 percent of cases. In turn, foreign branches are considered to have no significance for 85.5 percent of businesses.

Table 6. Distribution of KIS internationalised companies (CNAE-2009).

CNAE	Frequency	Percentage (%)
Telecommunications (61)	13	5.1
Programming, consulting and other computer science related (62)	13	5.1
Research and development (72)	10	3.9
Knowledge-intensive high-tech services	36	14.1
Sea transport and inland waterways (50)	7	2.7
Air Transport (51)	3	1.2
Real estate (68)	20	7.8
Rental and leasing activities (77)	6	2.3
Legal, accounting (69)	13	5.1
Activities of head office, management consultancy (70)	26	10.2
Architectural and engineering, technical testing and analysis (71)	32	12.5
Advertising and market research (73)	6	2.3
Other professional, scientific and technical (74)	25	9.8
Employment-related activities (78)	2	0.8
Security and investigation activities (80)	9	3.5
Office administrative, office and other ancillary enterprises (82)	2	0.8
Information services (63)	4	1.6
Knowledge-intensive market services	155	60.6
Education (85)	31	12.1
Health activities (86)	2	0.8
Motion picture, video and television program production, sound recording and music publishing (59)	14	5.5
Programming and broadcasting radio and television (60)	1	0.4
Creative, artistic and entertainment (90)	11	4.3
Libraries, archives, museums and other cultural activities (91)	6	2.3
Other Knowledge intensive-services	65	25.4
Total	256	

Source: The Authors.

Out of the total number of firms, only 12.1 percent have at least one overseas office, *i.e.* 31 companies, while the remaining 87.9 percent, representing 225 firms, have not been internationalized through foreign direct investment. The main countries where branches are located are in EU-15 countries (38.9 percent), Latin America (16.7 percent), other nearby markets (North Africa, 13.9 percent). Countries from the expanded EU-27 have been targeted to a lesser extent, as well as Asia and other developing countries.

4.3. Determinants in the Process of Internationalization

4.3.1. Ownership Advantages

The results of the survey show that Andalusian KIS companies generally consider the company's competitive advantages over its competitors in foreign markets to be of great importance in carrying out its process of internationalization (see [Table 8](#)). With regard to those aspects relating to the company's own assets, training is con-

Table 7. Methods of internationalization (%).

	No value	Low	Medium	High	Very high	Group of countries	%
Exports	12.9	21.9	24.6	19.1	21.5	EU-15	48.9
						EU-27	7.6
						Rest of Europe	2.2
						Near markets	13
						Developing countries	5.8
						Asia	4.0
						Latin America	18.4
Licencing	86.3	3.5	3.1	3.5	3.5	EU-15	37.1
						Developing countries	5.7
						Near markets	20
						Asia	5.7
						Latin America	28.6
						Others	2.9
Overseas branches	85.5	1.6	2.7	4.3	5.5	EU-15	38.9
						EU-27	11.1
						Near markets	13.9
						Developing countries	5.6
						Asia	8.3
						Latin America	16.7
Participation in a foreign company	89.5	2.7	1.6	2.3	3.9	EU-15	55.6
						Near markets	25.9
						Asia	3.7
						Latin America	11.1
						Others	3.7
Joint ventures	90.2	1.6	1.6	1.6	5.1	EU-15	44
						Near markets	28
						Asia	4
						Latin America	20
						Others	4
Bidding	87.1	2.3	2.3	2.7	5.5	EU-15	30.3
						EU-27	3
						Near markets	33.3
						Developing countries	3
						Latin America	27.3
						Others	3
Franchises	95.7	1.6	1.2	1.2	0.4	EU-15	45.5
						Asia	9.1
						Latin America	36.1
						Others	9.1
Others	60.2	1.2	2	3.1	2.3	EU-15	72.7
						Near markets	4.5
						Latin America	18.2
						Others	4.5

Source: The Authors.

Table 8. Ownership advantages (%).

	No value	Low	Medium	High	Very high
1. The company's own assets					
● Technology	5.1	7.4	30.1	38.3	19.1
● Innovation	3.9	4.7	23	44.9	23.4
● Leadership and management capacity	4.7	3.9	21.9	45.7	23.8
● Training	5.1	2.3	10.2	46.5	35.9
● Company size	10.5	13.3	50.8	19.9	5.5
2. Large financial capacity	9.8	18.4	53.1	14.5	4.3
3. Higher levels of competitiveness					
● Productivity	5.9	2.7	18.0	53.5	19.9
● Price competition	7.8	5.9	25.8	42.6	18
● Production costs	7.4	9.8	43.8	27.0	12.1
● Quality of service	2.3	0.4	5.1	42.2	50
4. Market positioning					
● Market share	6.3	5.9	25.4	48.0	14.5
● Image	3.5	2.3	8.2	38.3	47.7
5. Other	16	2	4.3	3.9	26.2

Source: The Authors.

sidered to be the most relevant, as this factor has been listed as having a high or very high importance by 82.4 percent of businesses. This is followed by leadership and management capacity (69.5 percent), innovation (68.3 percent) and technology (57.4 percent). On the contrary, the size of the company is not considered a key factor for accessing foreign markets.

With regards to higher levels of competitiveness against its competitors in the destination country, the idea that the quality of services is the most valued feature is given a very high or high importance by 92.2 percent of respondents. Following this is high productivity with 73.4 percent of cases and competitive pricing with 60.6 percent. However, the percentage of companies that consider lower production costs to be relevant is much lower.

With respect to market positioning, a high or very high relevance is assigned to image by 86 percent of companies, while market share is seen as important by 62.5 percent.

Therefore, we can say that the competitive advantages of Andalusian companies are based on the qualifications of the worker (blue collar and white collar), innovation, and technology, all of which enable higher levels of productivity and, therefore, higher quality and better prices. The importance of these advantages will also vary as a function of the destination country. For example, we think that in the case of the countries of the EU-15, having a higher level of development than ours, with higher costs, the competitive advantage is based more on price, while in the case of less developed areas such as North Africa and Latin America, the competitive advantage is based more on the superiority of the service.

In short, according to the opinion of businesses, the most valued competitive advantages would be the quality of service they offer and the professional training of employees, the latter of which is closely linked to the former, as well as to the image that clients have of the company.

4.3.2. Location Advantages

Companies that invest abroad consider a large number of factors related to the location and characteristics of the host country as determinant in their decision to situate themselves in another country (see [Table 9](#)). However, those factors related to characteristics of the market are considered to be very important (high and very high)

Table 9. Location advantages (%).

	No value	Low	Medium	High	Very high
1. Availability of resources					
● Low cost of labor	19.4	32.3	22.6	22.6	3.2
● Access to qualified personnel	12.9	32	38.7	32.3	12.9
● Infrastructure	16.1	12.9	35.5	22.6	12.9
● Technology resources	12.9	16.1	29.0	29.0	12.9
2. Market Characteristics					
● Market Size	6.5	6.5	19.4	48.4	19.4
● Market Growth	3.2	6.5	12.9	45.2	32.3
● Access to the domestic market	6.5	6.5	16.1	61.3	9.7
● Form of access to other foreign markets	6.5	3.2	22.6	48.4	19.4
3. Institutional factors					
● Favorable sector legislation	3.2	19.4	35.5	32.3	9.7
● Tax Incentives	16.1	22.6	38.7	16.1	6.5
4. Cultural Context					
● Quality of life of the country	22.6	25.8	9.7	35.5	6.5
● Corporate culture	19.4	19.4	19.4	29.0	12.9
● Language	16.1	16.1	16.1	32.3	19.4
5. Other					
● Absence of strong local companies	6.5	25.8	16.1	32.3	19.4
● Proximity to customers	3.2	3.2	12.9	54.8	25.8
● Proximity to suppliers	22.6	19.4	19.4	32.3	6.5
● Proximity to the university or research centers	51.6	12.9	22.6	9.7	3.2
● Proximity to clusters	41.9	9.7	32.3	16.1	-
● Monitoring the client	6.5	-	9.7	64.5	19.4

Source: The Authors.

which is consistent with what has been shown in many studies (see [74]). Specifically, market growth in 77.5 percent of cases, market size and access to the domestic market by 67.8 percent and 71 percent of respondents, respectively, and the form of access to other foreign markets by 67.8 percent. Thus, we can say that these service companies are fundamentally, as noted by Dunning [75] market seeking. As well, other factors stand out such as customer follow-up (83.9 percent) and proximity to customers (80.6 percent) and constitute the main reasons for these companies to invest abroad. This is logical because the service sector requires proximity to its customers to a greater extent than that of manufacturing, since many service businesses require the simultaneous production and consumption of the service, and thus the logic in locating the producer and the consumer in the same place, a fact that justifies the companies in these cases opting for foreign direct investment rather than exports.

Among the factors related to the cultural context are included the language, which is given a high or very high importance in 51.7 percent of cases, the quality of life in the country by 42 percent of respondents, and the corporate culture by 41.9 percent. However, at the other end of the spectrum, a large number of companies give a zero or low importance to these factors with 32.2, 48.4 and 38.8 percent, respectively. Therefore, we cannot conclude that these factors are decisive in the decision to locate abroad for these types of businesses.

For its part, within the institutional factors, favorable legislation for the sector is an important factor for 42 percent of companies. This is logical because the main destination for this investment is the service sector in other EU countries and, in particular, the professional services sector, which are closely linked to many knowledge-intensive services and are governed by a different law in each country and treated differently from the provisions of the country of origin. The liberalization of the service sector in the EU and its greatest exponent, the Services Directive (Directive 2006/123/EC of the European Parliament and of the Council of 12 December 2006 on services in the internal market, Official Journal L 376/36 of 27.12.2006) [76] tries to solve these problems and provides a general legal framework which favors the exercise of freedom of establishment for service providers as well as the free movement of services, while at the same time ensuring a high level of quality for services.

Finally, it must be pointed out that these businesses, being knowledge-intensive, do not consider it important to be located close to universities or research centers, nor close to clusters. In the first case 64.5 percent consider it of no or low importance, and in the second case 51.6 percent do so.

5. Conclusions

The internationalization of knowledge intensive services in Andalusia has materialized mainly through exports, relegating to the background the opening of branch offices abroad, in line with what happens in this process in the whole regional economy. Meanwhile, other more recent forms of internationalization such as joint ventures, franchising... are virtually out of the picture. Thus we can say that this process is still in its infancy and that in the coming years it should tend to become more advanced. The major destinations of these companies are fundamentally the EU-15 followed by Latin America, then North Africa and finally Asia.

Within the knowledge intensive services, there exists a large concentration of industries in certain branches of activity in terms of participation in the process of internationalization. Five of the twenty-two branches considered represent over 50 percent of companies, the most important technical services being architectural and engineering; testing and technical analysis services, education, head office activities; activities of management consultancy, other professional, scientific and technical services, and real estate. With the exception of education, the rest are business services and some of which are construction-related companies, a sector in Spain and the region that is highly specialized and has great competitive advantages. Also, the economic crisis has forced many companies to look for new markets abroad.

With respect to the factors which have affected the process of internationalization, the companies report as most important in terms of the competitive advantages that they possess: the quality of service which they offer and the image that customers have of the company, training for employees (which is closely linked to the previous advantage), leadership and management ability, innovation, technology. These results are logical given the characteristics that these activities demonstrate. As well, higher productivity compared to their competitors and competitive pricing are highly valued by them. However, they do not consider company size or production costs to be important competitive advantages. We can therefore say that the competitive advantages of Andalusian companies in knowledge intensive services are based on professional and managerial skill, innovation and technology, which encourage productivity gains, and thus higher quality and better prices.

Companies in knowledge-intensive services that invest abroad value the ability to monitor their customers and customer proximity as the most important location factors. They also consider as particularly relevant the factors relating to the target market. Thus, growth, access to the domestic and other foreign market and market size are considered very important by them. This was expected given that most industrial companies investing abroad are likely seeking efficiency in order to sell in other countries, but in the case of services, the necessary proximity between the supplier and the consumer of the service makes the market a key factor in the strategy of internationalization. Thus, the allocation of resources and especially the low cost of labor does not seem to be a determining factor for these companies. In addition, factors related to the cultural context and the institutional factors are not valued so greatly. In short, we can say that these knowledge-intensive service companies are seeking markets more than resources and, with respect to the latter, are seeking more advanced rather than basic resources, which is consistent given the nature of this type of activity.

6. Discussion

In brief, it can be said that although the level of internationalization of companies in knowledge-intensive services in this peripheral area is low based on the number of internationalized companies, those that have already begun

the process, although incipient, seem to be exploiting correctly the specific advantages that they have, and those companies investing abroad, although in relatively small numbers, can continue to consolidating this process of accessing other countries to make full use of the advantages of location relating to the market.

This paper contributes to the literature about internationalization of services, in particular, about Knowledge Intensive-Services in several ways. Firstly, we identify the international entry mode of these types of firms. Secondly, we indicate some ownership advantages of internationalized firms (export and FDI) and location advantages according to the opinion of foreign investors. Thirdly, we have conducted an original large database of internationalized Knowledge Intensive-Services.

In this context, our paper provides some interesting findings to help entrepreneurs in relation to decision making of the process of internationalization and to the policy makers to establish corporate policy measures that contribute to improving the context in which firms have to develop their expansion in other countries.

Finally, we must make it clear that an extension of this research could be to extrapolate this work to different countries so that the differences that may exist between them can be seen. Similarly, another study could consist in analyzing the sequence of the internationalization of these activities and determine whether the different pathways, such as exports or foreign investment, are complementary, alternative or independent. Likewise, we can study if these firms have followed a gradual process [77] or have carried out a rapid internationalization according to Born Global New Theories [51]. This would allow us to different features between both types of internationalization processes and their consequences.

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Appendix

BLOCK 1: General information about the firm

1. Sector (CNAE 2009)
2. In which year was the firm created?
3. The firm is a part of a group?
☐ Yes ☐ No (go to question 5)
4. If the firm is a part of a group. Is the firm a headquarter of a subsidiary?
☐ A headquarter. In which country is the subsidiary/(ies) located?
 If is located in Spain. In which region is it?
☐ A subsidiary. In which country is the headquarter located?
 If is located in Spain. In which region is it?
5. How many employees does the firm have?
☐ Between 1 - 9 workers
☐ Between 10 - 49 workers
☐ Between 50 - 250 workers
☐ More than 250 workers

BLOCK 2: International Markets

6. What is the importance of the following way of internationalization?

	No value	Low	Medium	High	Very High	Group of countries
1. Direct sale from Andalucía to customer in other countries	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2. Foreign customers coming to Andalucía	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3. Subsidiary in a foreign country in the firm provide its services	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4. Moving staff to other countries to provide services in these countries.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

7. What is the importance of the following channels on the international sales of the firm?

	No value	Low	Medium	High	Very High	Group of countries
1.Exports	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2.Licencing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.Overseas branches in other countries	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.Participation of a foreign company	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.Joint ventures	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
6.Bidding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
7.Franchisess	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
8.Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

8. Reason for the presence in foreign countries.

	No value	Low	Medium	High	Very High
Saturation of the domestic market	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Satisfying orders from foreign customer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Taking advantages of available resources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Taking advantages of a lower level of competition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Diversify markets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

9. Do you carry out Export activities regularly of its services?

- ☐ Yes. Since when?
- ☐ No

10. Total Turnover:

- ☐ Less than 2 milion euros
- ☐ Between 2 and 10 million euros
- ☐ Between 10 and 50 million euros
- ☐ More than 50 million euros

11. What is the percentage of the firms sales destined to other countries?

12. To whom does the firm sell its services in foreign countries?

- ☐ Final consumer
- ☐ Other firms: ☐ Agriculture ☐ Industry ☐ Construction ☐ Services

13. Does the firm carry out imports from other countries?

- ☐ Yes ☐ No (go to question 14)

If so:

13.1 What services?

<i>cnae</i>	<i>Sector name</i>
-------------	--------------------

13.2 Who is the seller?

- ☐ A third firm
☐ A firm of the group
☐ Headquarter
☐ Subsidiary

13.3 Since when?

13.4 From which countries?

BLOCK 3: Competitive advantages

14. What is the importance of the following characteristics of the firm as competitive advantages in relation to the competitors in the host country?

	No value	Low	Medium	High	Very High
a) The firm's own assets					
- Technology	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Innovation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Leadership and management capacity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Training	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Firm size	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b) Larger financial capacity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c) Higher levels of competitiveness					
- Productivity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Price competition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Production costs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Quality of service	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d) Market positioning					
- Market share	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Image	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e) Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

BLOCK 4: Location advantages

15. Does the firm have subsidiaries in foreign countries?

- ☐ Yes ☐ No (go to Block 5)

15.1. In which country is the headquarter?

16. What is the importance of the following characteristics of the host country as determinant factors in the decision to sell or/and produce the service in this country (subsidiary)?

	No value	Low	Medium	High	Very High
a) Availability of resources					
- Low cost of labor	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Access to qualified personnel	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Infrastructures	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Technology resources	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
b) Market characteristics					
- Market size	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Market Growth	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Access to the domestic market	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Form of Access to other foreign markets	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
c) Institutional factors					
- Favorable sector legislation	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Tax incentives	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
d) Cultural context					
- Q uality of life of the country	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- C orporate culture	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Language	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
e) Other					
- Absence of “strong “ local firms	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Proximity to customer	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Proximity to suppliers	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Proximity to universities or research centers	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Proximity to clusters	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>
- Monitoring of the client	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>	... <input type="checkbox"/>

17. Cost of the investment in the foreign country

- ☐ Less than 2 millions euros
- ☐ Between 2 and 10 million euros
- ☐ Between 10 y 15 million euros
- ☐ More than 15 million euros

18. When did the firm locate in a foreign country?

19. The foreign subsidiary...

- ☐ Produces services
- ☐ Sells services
- ☐ Produces and sells services

An Integrative Framework for Customizations on Satisfaction: The Case of an Online Jewelry Business in China

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Abstract

Upon the technological advancement of production flexibility, supply chain agility, and customer behavioral tracking, many online businesses now develop their customization strategies. In this regard, this study proposes an integrative framework for customization of product information, transaction handling, product attribute, and sales' service. We are interested in how these customizations affect customer satisfaction. From our web-based survey on a renowned online jewelry company in China, we collected 1383 responses from its customer database. Our findings showed that information, product and sales' service customizations have significant influence on customer satisfaction. Moreover, ordinary members as compared with VIP members feel more satisfied once they receive customized services.

Keywords

Customization, Satisfaction, Online Business

1. Introduction

With the technological advancement of production flexibility, supply chain agility, and customer behavioral tracking, many online businesses now develop their customization strategies. Early customization relies on customers' choosing product attributes to alter the default option and to create a unique product, which begins the era of mass customization (e.g. [1]-[3]). Coming along with sophisticated logistic and scheduling arrangement with suppliers and distributors in supply chain management, companies are capable to launch the "build to order" strategy (e.g. [4] [5]). Nowadays, customer relationship management enables companies to pay more attention to

the preferences and needs of an individual customer, and to serve customers differently according to their importance and value (e.g. [6] [10]).

Integrating all the above developments together, companies are now in full swing towards customization. Reference [9] has classified customization into three domains: transaction customization, information customization and product customization. Our framework extends customization on the service domain and is founded by the process of merchant brokering involving the evaluation of a product based on its features, possible options in choosing product attributes, price, warranty, availability, delivery time, payment options, and sales' services [11]. We look into customization over four different aspects: 1) product and promotional information, 2) payment and logistic options, 3) product attribute options, and 4) service levels. The followings highlight their current developments.

Information customization—With the assistance from business intelligence and data mining tools, customer databases are analyzed to extract customer preferences. Customized information, which would arouse the interest of a customer towards some new products, is pushed to the customer according to his/her shopping behavior. For instance, Amazon.com pushes customized information of new books based on the past purchases of a customer. Once the data-miner identifies a match between the interest of a customer and the latest products of thousands of small retailers which are attached to their zShops section, Amazon.com will pass the related information to the customer via email.

Product customization—Customized products are co-created with customers via mixing and matching product components from a list of options [12]. Upon satisfying individual needs, co-created products are more valuable than traditional and standardized products [13] [14]. Furthermore, a company can understand consumers' preferences based on their selections [12] [15]. Along this vein, Dell.com has achieved great success with its configuration system for customized computers via its online platform. Land's End allows its customers to co-design their own jeans and clothes with different combinations of color, fabric, style, and size. Priceline offers travelers different options to tailor-make their itineraries.

Logistic customization—Close relationships with the suppliers and logistic partners facilitate a company to arrange the production and delivery of a product. This is related to the flexibility of a company in handling build-to-order production and allows a company to offer different payment and logistic options to its customers. In this regard, automobile companies such as Toyota manage their supply chains and utilize their production plants for agile production. Peapod customers can also specify the delivery according to their own preference.

Service customization—Nowadays, companies are no longer holding up the preferential treatment to their VIP customers, instead, customized service is being served for an individual customer based on their needs and preferences. This would help build up the customer satisfaction and loyalty. Friend Finder (<http://www.friendfinder.com>), an online dating service, customizes its service levels ranging from self-serve to a customized service at different prices. To our knowledge, service customization has not been addressed much in the literature.

Compared with traditional business, customization in the online business depends much on the information technologies, which would be essential to provide customized information, to allow customers to specify their product, to offer customized payment and delivery arrangement, and to service the customers preferentially and differently. Moreover, competitions in online business are only a mouse click away from each other. Therefore, understanding customer satisfaction in an online store is critical and we hypothesize that customizations would be important for building up customer satisfaction. We also investigate if there are differences between two types of customers (ordinary and VIP members) on the theoretical predictions of our framework.

In order to testify our framework, we would like to select a business which pays much attention to customizing its products and services in order to fit the taste and preference of customers. Since customers are picky in selecting a luxury product, we select an online jewelry company in China for our data collection. According to [16], jewelry business is a kind of dynamic mass-market. Hence, mass service customization would be the right approach to dealing this business. In general, customers would be more impressed by the customizations in an online store selling luxury products than that in other online businesses on necessity products.

Today, most customers usually do not hesitate when they purchase inexpensive items online, such as books or clothes. This habit is migrating towards luxury products. For example, Blue Nile (www.bluenile.com), the most well-known US-based online jewelry retailer sold more engagement jewelry than Tiffany & Co. This provides indisputable evidence that online jewelry business is now grabbing a considerable share of the market. In 2011, Blue Nile reported that its first-quarter net sales had increased 8.3% quarter-on-quarter to US\$80.2M from NILE

news in Nasdaq. These figures show that people are just as willing to pay for luxury-brand items from well-established US online markets as they are from retail shops.

While evidence from the US confirms the success of selling luxury products online, it is not clear how well the situation will translate into other cultural contexts, such as that of mainland China, in which the online jewelry business is still in the developmental phases. According to [17], there are similarities and differences between US and Taiwanese respondents in the acceptance of online apparel customization. China is a promising market for online businesses. By the end of 2010, the total number of “netizens” in China reached 457 M, representing 34.3% of the entire population and around one-third of the online market was related to diamond sales in 2011 from China Internet Network Information Center.

In particular, the law in China mandates that all diamonds and other types of jewelry be certified by the National Gemstone Testing Center (NGTC), the National Gold and Diamond Testing Center (NGDTC), or the Gemological Institute at the China University of Geosciences (GIC). NGTC and NGDTC are the foremost national-level authorities in diamond grading and jewelry certification in China, while GIC is the most respected independent authority on gemology, diamond grading, jewelry education, and certification and gemology research. Certification from these organizations is a key indicator of authentication and foundation of trust building among online jewelry businesses in China. Besides the brand name of the online jewelry store, consumers buying online jewelry in China rely on this rigorous certification process as relevant authorities will regularly police on the genuineness of those certificates. Nowadays, more consumers are buying their jewelries online than ever before, especially if they believe that they have found a reliable website. Moreover, testing our research model in the context of an online jewelry business will provide practitioners some helpful insight into customization strategies.

2. Theoretical Framework

Customization is defined as the tailoring of products and services to customers’ individual needs. In the early studies, [18] suggested four approaches to customization: collaborative, adaptive, cosmetic and transparent. In the collaborative approach, companies customize products for customers based on different components and configurations of a product. The adaptive approach attempts to create a product which is customizable once it is in the hands of customers. For the cosmetic approach, standardized products are offered but with different options for their packaging. Using the transparent approach, a company designs its products based on the needs of their target customers. These approaches, which are not exclusive to each other, provide a framework for companies to determine their customization strategies. According to [19], customization is a continuum of strategies that depend on which parts of the manufacturing process lean toward standardization or its counter side—customization. Nevertheless, the attitudes toward online mass customization are highlighted to be very important for intention to purchase and word of mouth [20].

In an online context with rich interactive media, customization covers a broader spectrum not exclusively limited to manufacturing process. Reference [21] proposed a buyer-centric strategy, which focuses to help customers identify their needs. Buyer-centric companies treat customers as active co-producers of products and services being offered via the Internet platform. An online company associated with buyer-centric strategy becomes an agent of the customer, ‘renting’ out to the customers pieces of its manufacturing, logistics, and other resources and allowing them to find, choose, design, and use what they need [21].

Those online buyer-centric companies need to address how they can collaborate with their customers in their manufacturing and business processes. As [22] suggested, the scope of customization requires companies to understand its underlying technology. Advanced databases and data-mining techniques allow online companies to analysis the behavior and preferences of their customers. As a result, customized information, products and services can be pushed to their customers in a cost-effective way. Furthermore, [23] identified five different types of customers using cluster analysis, which are namely as unfaithful, ordinary, experientialists, purposive and loyal experts, based on the four dimensions of online customer heterogeneity: value, knowledge, orientation and relationship. They proposed that an online company should treat customers differently according to their types.

Reference [24] suggested four areas of research towards customization, namely 1) the economics of search, 2) cognitive cost approaches, 3) constructed preference approaches, and 4) phenomenological approaches. This article establishes a more holistic approach towards customization.

Customization is particular important for companies delivering products and services which are associated

with the living style and taste of a person. Reference [16] proposed that joint alliance service customization would cater for a business which pushes dynamic information to individual consumers.

Beside [9] who investigated the alignment of three customization strategies (transaction customization, decision customization, and product customization) with three product types (convenience goods, shopping goods and specialty goods), there are no studies examining the impacts of customizations in an extensive manner. This study attempts to examine customizations involving information searching, transaction arrangement, product design and sales' service on customer satisfaction in an online business. Our integrative framework is discussed in details as follows.

2.1. Information Customization and Customer Satisfaction

Information customization signifies the multiple ways in which companies can arrange and organize online information (in terms of display and content) to reflect their customers' preferences [25]. Often, customers are overwhelmed with the plethora of products and services available. With an established customer database, a company would easily keep track the behavior and preference of its customers. Upon the login of a customer, the online store can tailor information content and push to the customer via popup banner and other cues. This would help customers identify their needs and facilitate their decision making in an effective way.

Reference [26] stated customer satisfaction is related to two stimuli—an outcome and a comparison referent. A customer feels satisfied when he/she has greater experience than his/her expectation. In usual, the website of an online store provides the latest information about their products. The comparison referent is based on the experience of visiting these websites. In case a website gives customized information dynamically to individual customers, this will generate greater experience than that in the common referent. Hence, information customization on an online store will induce high customer satisfaction and we propose the following hypothesis:

H1: Information customization has a significant positive impact on customer satisfaction.

2.2. Transaction Customization and Customer Satisfaction

Transaction customization refers to different logistic and payment options for customers in handling a transaction and allows customers to complete and to trace a transaction conveniently. Reference [25] hypothesized that transaction inconvenience is a factor contributing to the high abandonment rates of shopping carts in electronic retailing. The frustration that the customers encounter in the online transaction experience with inconvenient electronic shopping carts or processing speed is similar to that of waiting in long lines at a retail store. Ultimately, as [27] explained, customizing the transaction process for customers allows “individuals to complete their transactions more efficiently”. The speed of the transaction is also a vital component of transaction customization. Based on the profile of a customer in the customer database, an online store would save the customer's effort in the address and payment details of an order.

Moreover, it is important for customers to decide on the payment and logistic arrangement based on a list of options. The well-known gardening and landscaping website garden.com provides us with an example of transaction customization. On garden.com, shipping arrangements and delivery scheduling are preset according to customer preference in their past transactions. Certainly the customer can modify the preset to some other options if necessary. On the other hand, in nowadays' online business, customers would also trace their sales history and order status online in real time through the website of the online store. We argue that for a company providing convenience for customers in handling and tracing their transactions in terms of payment and logistic arrangement in a more customized way, the higher will be the satisfaction of the customers. Hence, we put forth the following hypothesis:

H2: Transaction customization has a significant positive impact on customer satisfaction.

2.3. Product Customization and Customer Satisfaction

Product customization provides a means for customers to specify their products according to a wide variety of options and accessories in specifying a product. It relies on advanced manufacturing using modular design in a product. Product customization is the adaptation of products to the individual tastes and needs of consumers [9]. Involving customers in the process creates a sense of ownership for the customers. When customers design a unique product, they feel a sense of accomplishment (the “I designed it myself” effect) [28]. Buying a ready-

made product generally provides the customer a lower degree of psychological ownership [29]. Therefore, many companies consider the “I designed it myself” effect and allow customers to design their unique products [2] [30]–[32].

Along with the “I designed it myself” effect, customers are empowered by designing their own products using the interactive platforms provided by online retailers. Companies allow customers to experience the feeling of “having an impact” on the product. By participating in the process, customers’ feelings of self-efficacy (a “can-do” attitude) and responsibility lead to stronger feelings of ownership [33].

This is consistent with the literature on empowerment in general: when people are allowed to participate actively in decision-making that may influence the final outcome, the decisions become their decisions [34]. In other words, people assume psychological ownership of such decisions because they are partly responsible for the outcome, and this tends to elicit positive feelings of satisfaction [35] [36]. This would bring the happiness and pleasure during the process. Therefore, a highly customized product increases the likelihood of customer satisfaction. This leads to the following hypothesis:

H3: Product customization has a significant positive impact on customer satisfaction.

2.4. Service Customization and Customer Satisfaction

Service customization focuses on serving customers preferentially and in different manners. It is a kind of customization because it caters for the unique wants and needs of different customer types by providing them with specific services, social benefits and treatment [37] and is for building, developing and maintaining targeted customer types [23] [38]–[40]. For instance, while VIP members get a complementary gift along with their purchase because of their status, ordinary members will also be happy after receiving an electronic greeting during their birthday month. These tailored services such as personal recognition, discounts, price breaks and extra attention, offer unique value to customers [40] [41]. Service customization would help companies build and stabilize the relationship between different types of customers and the company [42].

Upon the value of customized service, some researchers have suggested that customers typically compare themselves with “similar others” [43]. This need for comparison is pervasive, even though customers make the comparisons unintentionally [44] and without self-awareness [45]. With time, customized service may make customers feel special and entitled to adulation [46]. Numerous researchers have concluded that people feel better when they perceive themselves to be served differently and preferentially [47] [48]. These customized services would be so personalized that would not be applicable to other customers. Such a feeling might enhance the relationship of a customer with the company [49] [50]. Research has confirmed that customized service can be used to establish a good customer relationship [51] [52], which may also lead to customer satisfaction. Hence, we predict the following hypothesis:

H4: Service customization has a significant positive impact on customer satisfaction.

2.5. Control Variables

Perceived value is defined as the net benefits customers gain in proportion to their costs, including the amount paid and the related transactional cost [53] [55]. What constitutes value seems to vary widely from one person to another [54] [55]. However, the impact of perceived value on satisfaction cannot be neglected; a considerable amount of research has focused on identifying the impact of perceived value on customer satisfaction [56]–[58]. This study also considers perceived value as an important factor on customer satisfaction.

The backgrounds of users may influence their online shopping behavior. Prior online shopping experience, for example, may be proportionate to satisfaction. Moreover, the education of users sometimes increases with their understanding of online shopping. Different levels of understanding result in different presumptions, influencing user satisfaction. Therefore, it was necessary to control the possible effects of gender, age, prior shopping experience and education on satisfaction. The theoretical framework is shown in **Figure 1**.

3. Methodology

To measure the constructs, we adopted validated items used by other researchers. All of the constructs were assessed using a 7-point scale from 1 (strongly disagree) to 7 (strongly agree). The measurement on customizations of information delivery, transaction handling and product design are adopted from [9]. These constructs

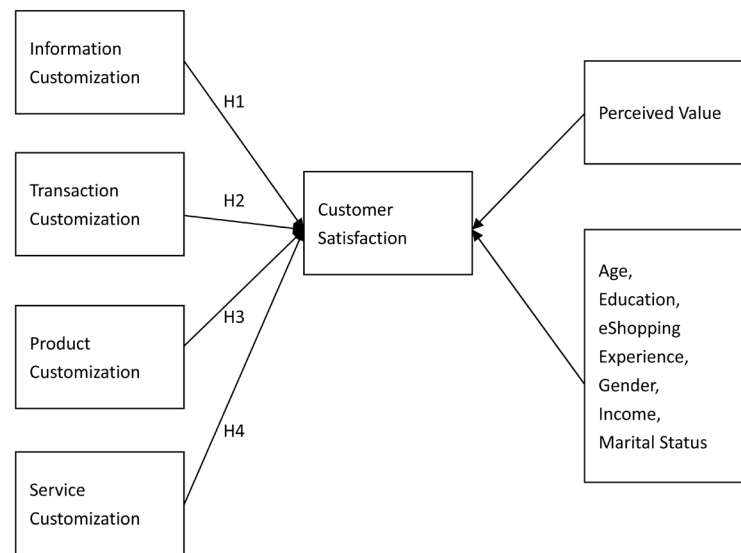


Figure 1. Research model.

were measured through survey statements such as “this online store recommends customized information on products that you may be interested in based on the website’s best-selling products”; “this online store allows you to update your shipping, billing, and payment information conveniently”; and “this online store allows you to state your preference on the design of a product”. The measurement of service customization is modified based on the concepts from [40] [59]. This construct consists of items such as “this online store serves you in a good way that is unlikely happened in other customers”. The construct of satisfaction is assessed by the scale developed by [60] and included items such as “You are satisfied with your decision to purchase from this online store”. For the control variables, perceived value is adapted from [61] with items such as “Compared to alternative websites, this online store fairly charges for similar products/services”.

The profile of a respondent was collected at the end of the questionnaire. Membership was coded with ordinary member as 0 and VIP as 1. Gender was coded with 0 for “female” and 1 for “male”, while marital status was coded with 0 for “single” and 1 for “married”. Age was coded with 1 for “below 20” and 5 for “36 or above”. Similarly, education was coded with 1 for “primary school” and 5 for “postgraduate”, while the online shopping experience was coded with 1 for “less than one year” and 5 for “more than four years”. Annual income was coded with 1 for “below RMB30,000” (US\$4635) and 7 for “RMB300,001 or over”.

A professional translator fluent in both Chinese and English was hired to translate the Chinese version of the survey to English. After the translation process, we verified both the English and Chinese versions to ensure they were of identical meaning before sending them out. The Chinese version was also back-translated to English to ensure both versions have identical meaning. The essential items in the survey are shown in [Table 1](#).

3.1. Sampling

We conducted a questionnaire-based survey for an online jewelry company in China on March 2011. This online company was founded by a well-known jewelry manufacturer in the international market with a strong position in the industry. The average amount in each purchase was fallen within a price range of RMB1000-5000 (around US\$150-770). There were totally 4122 active online customers purchasing from this online company till up to March 2011. According to its membership structure, customers who made more than two purchases since the store open in 2008 are promoted to VIP members. Otherwise, they were all ordinary members. Nevertheless, this online company was acquired by an US investor who decided to transform it to some other online business in late 2012. Hence, this online company was close down in November 2012.

The cover page of the online survey stresses on confidentiality in handling the data. To ensure validity in filling the questionnaire, all respondents were reminded to read and answer the survey carefully. To ensure the clarity and understandability, hyperlinks leading to a specific icon or function in the website of the online company were shown along with the questions. In addition, two part-time research assistant were hired to send

Table 1. Constructs in the framework.**Information Customization (IC)**

IC1 This online store recommends customized information on jewelry products that you may be interested in based on the website's best-selling products.

IC2 This online store recommends customized information on jewelry products that you may be interested in based on the comments of those hot items.

IC3 This online store recommends customized information on jewelry products that you may be interested in based on the items you searched for and purchased on the website.

IC4 This online store recommends customized information on complementary jewelry products that are relevant to you.

Transaction Customization (TC)

TC1 This online store allows you to review your purchase history in a customized manner.

TC2 This online store allows you to update your shipping, billing, and payment information conveniently.

TC3 This online store allows you to check the status of your order conveniently.

TC4 This online store allows you to save items in a shopping cart for your future return in an easy manner.

TC5 This online store provides a variety of payment and delivery options.

TC6 This online store provides satisfactory payment and delivery options.

Product Customization (PC)

PC1 This online store allows you to state your preference on the design of a product.

PC2 This online store allows you to specify your product.

PC3 This online store helps you better determine your product requirements.

PC4 This online store actively participates in building the product features that you want.

PC5 This online store actively aids you in identifying which product attributes that fit your needs.

Service Customization (SC)

PT1 This online store serves you in a good way that is unlikely happened in other customers.

PT2 This online store usually places your request in a high priority.

PT3 This online store provides you with fast service that is unlikely happened in other customers.

PT4 This online store provides you with good treatment that is unlikely happened in other customers.

PT5 This online store provides you with special treatment that is unlikely happened in other customers.

Perceived Value (PV)

PV1 Compared to alternative websites, this online store fairly charges for similar products/services.

PV2 Compared to alternative websites, this online store provides more free services.

PV3 When you compare what you have paid to what you might receive from other competitive website, you think this online store provides you with a good value.

Satisfaction (SA)

SA1 You are satisfied with your decision to purchase from this online store.

SA2 Your choice to purchase from this online store was a wise one.

SA3 You think you did the right thing in buying from this online store.

emails, text messages and phone calls to remind its customers to fill in the online questionnaire.

This survey, as with most others, provided an incentive to respondents. Reference [62] stressed that around 57% of Web-based surveys offer participants an incentive in order to obtain a reasonable response rate. In order to encourage people to respond to our survey, respondents who completed a questionnaire were entered into a lucky draw with a prize of RMB50 in cash. In total, there were 350 prizes.

All 4122 active customers (the ordinary and the VIP members) of the online jewelry company have received an email for the online survey. With the reminders via email and SMS, 1581 responses were received. Among those responses, 198 returns were invalid because of extensive missing values or some special patterns such as same score for all questions. After taking away the 198 invalid questionnaires, there were 1383 valid questionnaires remaining, of which 880 were from ordinary members and 503 from VIP members.

The demographic profiles of the two samples are presented in **Table 2**. The samples offer a good representation of the population. The respondents who are ordinary members represent around 25% of the ordinary member pool. Similarly, the respondents who are VIP members represent around 65% of the VIP pool, with some slight variations. Owing to a good relationship with the company, VIP members have a higher response rate. Of the 1383 valid respondents, 47% were male and 53% were female; the ratio of males to females was 0.88:1. The respondents were generally well educated, with 75% having an undergraduate degree in both the ordinary and VIP groups. Almost all respondents reported having online shopping experiences in the past few years. The “younger” groups (with ages of 21 to 30) accounted for more than 70% of the online purchase from the online jewelry company. More than 60% of the respondents were single. The annual income of the respondents was concentrated in the lower-income bands. Around 45% (47% of the ordinary members and 39% of the VIP members) of the participants earned below RMB30,000, and 33% of the respondents were within the annual income range of RMB30,001 - 60,000 (the next-lowest band). Between 1% and 7% of the total population fit into the remaining earning bands (RMB100,001 or above).

3.2. Reliability and Validity Testing

A factor analysis was carried out on all 26 items in our model on customer satisfaction to reduce the number of items in each construct while maintaining its reliability and discriminant validity. Factors were extracted via the principal component and varimax rotation method. Variables were eliminated if not factorially pure. **Table 3** summarizes the factor analysis results, which confirmed that 23 items should remain for the subsequent path analysis.

Those items that did not load strongly on any factor (values below 0.7) or those that had cross-loadings were eliminated. A total of three items—PC1, PC2, and TC6 were, therefore, deleted. After further checking with the senior executives of the online jewelry company, the options allow a customer to state their product design (PC1) and to customize their product (PC2) are only available for some expensive products and are not obvious in the website. Hence, the respondents may not have consistent responses to the items PC1 and PC2. On the other hand, TC6 was also dropped due to cross loading with other constructs.

Reliability, as shown in **Table 4**, refers to the extent to which a construct is free from errors and yields consistent results. Cronbach’s alpha was used to measure the internal consistency of the multi-item scales used in this study. As the values of Cronbach’s alpha for all constructs were over 0.7, they were deemed reliable. Moreover, we adopt the measurement from constructs used in past studies and the questionnaire was validated by a MIS professor and an expert in customer behavior prior to distribution, the content validity of all the constructs were acceptable.

Table 4 shows the values of the average variance extracted (AVE), which determines the average variance shared between a construct and its measures, of the three antecedent constructs. The AVE of a construct is calculated by the sum of loadings squared divided by the number of items in the construct. The AVE of any construct should be higher than 0.5 for the construct to be reliable.

The correlation matrix of the data set is shown in **Table 4**. This enables us to examine all potentially overlapping constructs. If the items comprising a construct do not overlap much with other constructs (that is, the AVE of a construct is larger than its squared inter-correlations with other constructs), then the discriminant validity of the construct is assured [63]. **Table 4** shows that the diagonal elements (reporting the square root of the variance shared between a construct and its measures) are all higher than the correlations indicating the discriminant validity of all the constructs in this study.

Table 2. Profile of survey respondents.

Type Demographic dd Demographics	Ordinary Members				VIP Members				Total
	n1		N1	% (n1/N1)	n2		N2	% (n2/N2)	N
Gender									
Male	412	47%	1592	26%	237	47%	377	63%	1969
Female	468	53%	1768	26%	266	53%	385	69%	2153
Marital Status									
Single	527	60%	1.984	27%	293	58%	442	66%	2426
Married	353	40%	1.376	26%	210	42%	320	66%	1696
Age (years)									
Below 20	77	9%	289	27%	31	6%	53	58%	342
21-25	397	45%	1497	27%	215	43%	321	67%	1818
26-30	254	29%	958	27%	170	34%	260	65%	1218
31-35	107	12%	428	25%	50	10%	80	63%	508
36 or above	45	5%	188	24%	37	8%	48	77%	236
Education									
Primary School	4	0.5%	20	20%	0	0%	1	0%	21
Secondary School	25	3%	116	22%	16	3%	29	55%	145
Diploma/Higher Diploma	137	16%	625	22%	76	15%	116	66%	741
Undergraduate	662	75%	2399	28%	384	76%	570	67%	2969
Postgraduate	52	6%	200	26%	27	5%	46	59%	246
e-Shopping Experience									
Less than 1 year	162	18%	650	25%	50	10%	83	60%	733
1-2 years	205	23%	825	25%	126	25%	192	66%	1017
2-3 years	215	24%	801	27%	137	27%	201	68%	1002
3-4 years	129	15%	473	27%	81	16%	120	68%	593
Over 4 years	169	19%	611	28%	109	22%	166	66%	777
Annual Income (RMB)									
Below 30,000	410	47%	1.620	25%	194	39%	315	62%	1935
30,001 - 60,000	291	33%	1.082	27%	169	34%	245	69%	1327
60,001 - 100,000	104	12%	339	31%	64	13%	101	63%	440
100,001 - 150,000	26	3%	96	27%	36	7%	48	75%	144
150,001 - 200,000	19	2%	83	23%	20	4%	23	87%	106
200,001 - 300,000	13	1%	69	19%	9	2%	13	69%	82
300,001 or above	17	2%	71	24%	11	2%	17	65%	88

Population: N = Total (4122); N1 = Ordinary Members (3360); N2 = VIP Members (762). Sample: N1 = Ordinary Members (880); N2 = VIP Members (503).

Table 3. Results of factor analysis.

Item	Ordinary Members						VIP Members					
	IC	TC	PC	SC	PV	SA	IC	TC	PC	SC	PV	SA
IC1	0.782	0.047	0.053	0.063	0.097	0.177	0.727	0.065	0.017	0.060	0.102	0.144
IC2	0.749	0.162	0.179	0.096	0.007	0.114	0.717	0.035	0.121	0.075	0.032	0.031
IC3	0.743	0.180	0.128	0.112	0.168	0.049	0.698	0.075	0.096	0.000	0.081	0.077
IC4	0.729	0.152	0.177	0.092	0.127	0.003	0.690	0.064	0.030	0.018	0.152	0.042
TC1	0.158	0.672	0.175	−0.038	0.164	−0.129	0.053	0.732	0.093	−0.012	−0.102	0.149
TC2	0.126	0.694	0.057	0.099	−0.098	0.192	0.145	0.669	0.076	0.141	−0.203	0.209
TC3	0.079	0.772	0.056	0.064	−0.002	0.123	0.092	0.772	0.036	0.051	0.024	−0.024
TC4	0.145	0.764	0.094	0.022	−0.023	0.065	0.038	0.707	0.117	0.050	0.088	−0.042
TC5	0.044	0.705	0.199	0.069	0.168	−0.129	−0.029	0.631	0.159	0.011	0.247	−0.121
PC3	0.203	0.198	0.705	0.113	0.120	0.189	0.071	0.191	0.768	0.018	0.079	0.119
PC4	0.206	0.191	0.793	0.072	0.101	0.081	0.104	0.142	0.833	−0.010	−0.019	0.029
PC5	0.131	0.156	0.778	0.139	0.126	0.165	0.102	0.084	0.795	0.003	0.099	0.116
SC1	0.123	0.039	0.032	0.772	0.087	0.127	0.060	0.065	0.003	0.763	0.094	0.058
SC2	0.061	0.064	0.127	0.830	0.080	0.159	0.032	0.058	0.027	0.876	0.013	0.071
SC3	0.100	0.080	0.068	0.864	0.126	0.130	−0.002	0.035	0.025	0.894	0.043	0.086
SC4	0.063	0.050	0.075	0.863	0.147	0.062	0.046	0.021	00.00	0.911	0.034	0.043
SC5	0.059	0.009	0.076	0.858	0.148	0.073	0.053	0.045	−0.032	0.859	0.038	0.077
PV1	0.170	0.008	0.097	0.161	0.718	0.261	0.171	−0.002	0.056	0.057	0.730	0.338
PV2	0.066	0.061	0.132	0.167	0.733	0.272	0.140	0.047	0.053	0.117	0.810	0.218
PV3	0.146	0.072	0.104	0.188	0.793	0.176	0.173	0.003	0.078	0.045	0.785	0.338
SA1	0.198	0.068	0.157	0.211	0.338	0.703	0.106	0.060	0.076	0.122	0.272	0.788
SA2	0.116	0.036	0.201	0.218	0.294	0.760	0.113	0.032	0.102	0.116	0.254	0.855
SA3	0.118	0.053	0.189	0.202	0.394	0.666	0.119	0.030	0.137	0.094	0.288	0.816

Table 4. Squared correlations, reliability, and average variance extracted.

Construct	Ordinary Members						VIP Members					
	1	2	3	4	5	6	1	2	3	4	5	6
1: IC	0.75						0.70					
2: TC	0.35	0.72					0.19	0.71				
3: PC	0.44	0.41	0.76				0.23	0.31	0.80			
4: SC	0.25	0.15	0.28	0.84			0.12	0.13	0.03	0.86		
5: PV	0.34	0.17	0.38	0.39	0.75		0.33	0.08	0.20	0.16	0.77	
6: SA	0.37	0.18	0.46	0.43	0.66	0.71	0.28	0.13	0.25	0.22	0.59	0.82
Reliability	0.80	0.79	0.78	0.91	0.78	0.83	0.70	0.76	0.76	0.92	0.84	0.88
AVE	0.56	0.52	0.58	0.70	0.50	0.51	0.50	0.50	0.64	0.74	0.60	0.67

We conducted the Harmon one-factor analysis suggested by [64] to check for the presence of common method bias. A factor analysis combining all major variables in the research framework (information customization, production customization, service customization, perceived value and satisfaction) detected no single factor explaining the majority of variance. For ordinary members, single-factor analysis shows 30.5% of the explained variance, whereas for VIP members, 22.9% of the explained variance is detected in the single-factor analysis. In addition, results of the structural models showed different degrees of significance for path coefficients. These facts suggest that common method bias is not a serious concern in this study.

We conducted a non-response bias analysis by testing for significant differences between the means of early and those of late respondents, with the late respondents considered as surrogates for non-respondents [65], using t-tests at a 0.05 significance level. We divided all valid samples in half. The first batch included 50% of the responses collected (440 of the total 880 samples collected for ordinary members; 251 of the total 503 samples collected for VIP members). These responses were compared with the remainder of the responses collected later. Our results indicated no significant difference between the two waves of responses. This suggests that non-response bias is not a concern with this study.

4. Analysis and Findings

Judging by the standard deviations of all of the items, the sampled data had enough variations to represent the population (see Table 5). The means of information customization further suggest that ordinary members and VIP members had about the same perception of information customization. This would indicate that both types of customers appreciate the organization and the presentation of information provided by the online jewelry company.

By looking at the mean values of product customization, service customization, perceived value, and satisfaction, we are surprised that ordinary members are more favorable toward the online jewelry company than VIP members. After discussing this finding with senior executives of the online jewelry company, we understood that the focus of this company was on market penetration. Hence much attention has been given to ordinary members especially those who have made their first purchase. Customized information is pushed to them via emails and short message services. There are also specific services—such as educating ordinary members on how to judge the quality of diamonds. Immediate service repairs, flexible customer return and refund policies, are also offered to ordinary members. As a result, ordinary members would be more satisfied than the VIP ones.

Regarding transaction customization, our findings as shown in Table 5 suggests that customers trust services provided by certain well-established third parties. It is because this online jewelry company customizes payment and logistic arrangement according to the services as provided by Alipay and SF Express in China, which are popular payment gateway and parcel carrier respectively. These companies are seen as useful, reliable and trustworthy; therefore, both ordinary and VIP members perceive transaction customization more favorably than information and product customization.

Online companies customize their services to different types of customers according to their marketing tactics. Often, this kind of service is provided only to VIP members because speeding up the normal production time from weeks to a few days involves various operational arrangements and resources reallocations. Due to recent severe competition in China, many online stores in China tend to treat their potential and existing customers

Table 5. Descriptive statistics and reliability of constructs.

Construct	Ordinary Members	VIP Members	Differences
	Mean (S.D.)	Mean (S.D.)	Mean (Ordinary Members)—Mean (VIP Members)
Information Customization	5.79 (0.72)	5.80 (0.70)	−0.01
Transaction Customization (5)	6.21 (0.68)	6.35 (0.64)	−0.14***
Product Customization	5.85 (0.80)	5.72 (0.83)	0.13**
Service Customization	5.45 (1.03)	5.23 (1.19)	0.22**
Perceived Value	5.51 (0.83)	5.36 (0.93)	0.15**
Satisfaction	5.64 (0.82)	5.51 (0.91)	0.13**

preferentially for market expansion. For example, an ordinary member (or a potential customer) may inquire about an expensive diamond ring in the online jewelry store. Due to the potential value of this purchase which indicates the importance of the customer, a jewelry consultant will contact the customer directly, either through email or over the phone. With a specific monetary guarantee, such as a credit card deposit, the diamond ring will be delivered to the customer for inspection. If the customer decides not to purchase, he/she need to return the diamond without any charge by courier within a specified period.

To test our hypotheses, we used structural equation modeling from AMOS [66] [67]. This provides goodness-of-fit measures for the estimated models that access absolute-fit measures, such as chi-square statistics goodness-of-fit (GFI), and root mean square residual (RMSEA) and incremental fit measures, such as degree of freedom and the adjusted goodness-of-fit index (AGFI), in addition to parsimonious-fit measures such as the comparative fit index (CFI). As shown in Table 6, all indices of both structural models meet the terms of [68] combinational rule, providing evidence of a good model fit.

Figure 2 illustrates our analyzed results for the ordinary and VIP members. The findings from both structural equation models indicate that annual income, e-shopping experience, and age do not have a significant effect on satisfaction, while marital status shows a negative coefficient with $p < 0.05$, indicating that married customers are less satisfied than single ones within the ordinary member group. Moreover, gender has positive coefficients with $p < 0.05$ and $p < 0.1$ for ordinary and VIP members, respectively, indicating that females are less satisfied than males within both customer groups.

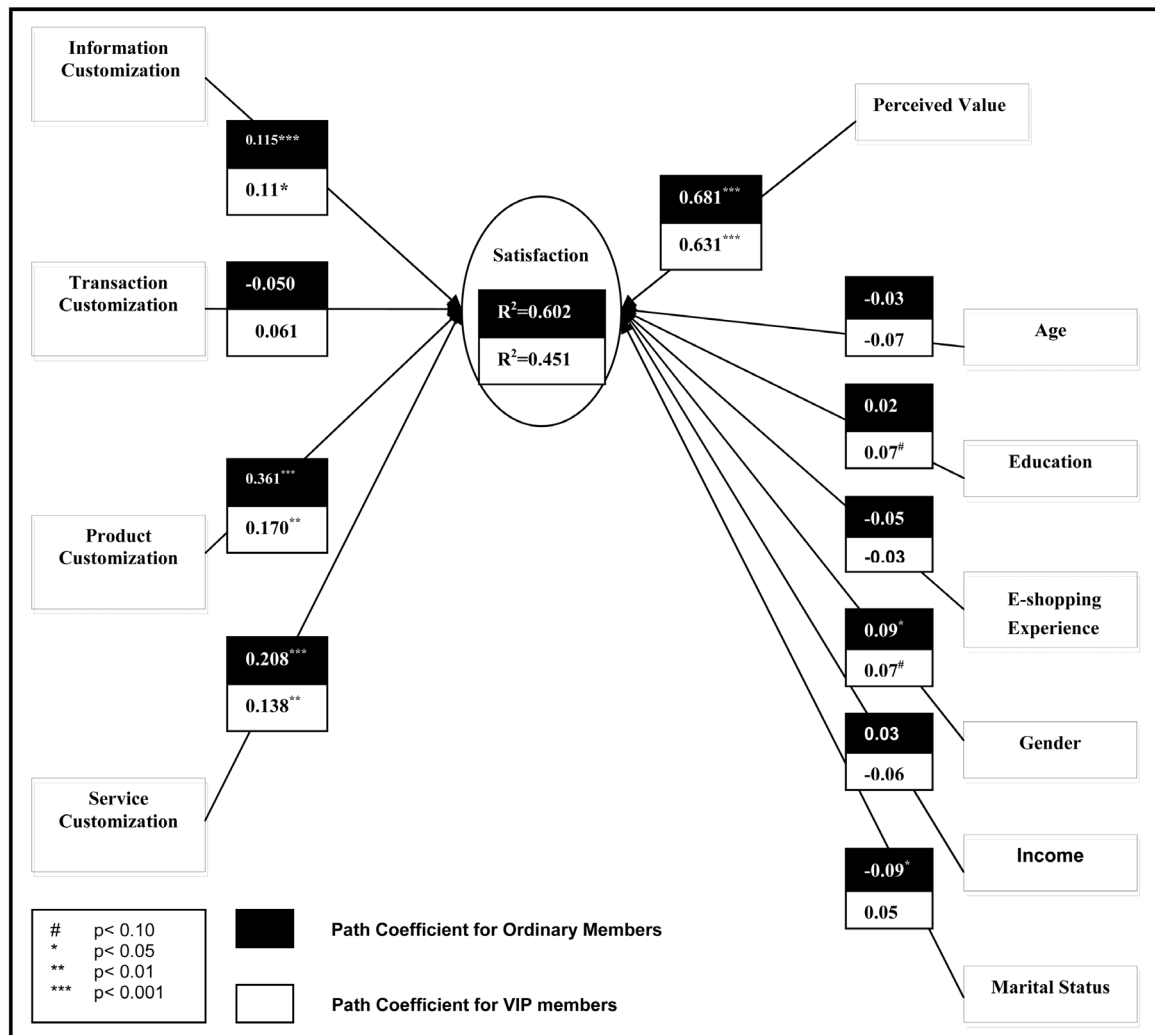


Figure 2. Structural models (Ordinary vs. VIP members).

Table 6. Structural model fit-multi-group analysis.

Fit indices	Both types of customers (Ordinary and VIP members)	Desired levels
χ^2/df	2.458	<3.00
CFI	0.935	>0.90
RMSEA	0.032	<0.08
GFI	0.908	>0.90
AGFI	0.890	>0.80
IFI	0.938	>0.90

From our analysis as shown in **Figure 2**, information customization, product customization and service customization all have a significant impact on satisfaction for both types of customers. Product customization has the strongest positive impact on satisfaction for ordinary and VIP members. Results showed that H1, H3, and H4 are supported in both samples. Nevertheless, H2, which states that transaction customization has a significant impact on satisfaction, is not supported for either type of customers. In addition, the explained variances (r-squared) of satisfaction for ordinary and VIP members are 0.60 and 0.43 respectively.

5. Discussion

The results ($\beta = 0.115^{***}$ for ordinary members and $\beta = 0.110^*$ for VIP members) suggest that information customization has a positive impact on satisfaction for both types of customers. Customers are pleased with latest customized information on products and promotions while they login the online jewelry company. These product information and promotions are highlighted by various headings and sidebars. Given a variety of choice without much disturbance, customers visiting this website can have much leisure in comparing different products on their interests. This provides a better environment as compared with the traditional jewelry store. Shopping online for inexpensive items would normally demand less for product information than that of expensive items. As customers (both ordinary and VIP members) are pleased with the customized information provided by the company, it is reasonable that they are both satisfied.

The results show that transaction customization, unlike information customization, has no impact on satisfaction for either ordinary members or VIP members. The transaction arrangement may be less important when compared with information and product customization which are more related to the decision for making a purchase especially on those personalized products like jewelry. Moreover, as from the descriptive statistics, we suspect that the customized services as provided from the third party logistic and payment providers which are trustworthy. Hence it is also reasonable that these customized services do not have impacts on satisfaction with the company.

Our findings show that product customization affects the satisfaction of both types of members. This is reflected in the path coefficients of 0.361^{***} and 0.170^{**} for product customization, regarding satisfaction of ordinary and VIP members, respectively. Though ordinary members purchase in small amounts on jewelries upon their first time from an online store, they do want to have their own customized products. For instance, the following illustrates how a customer customizes a diamond ring. With an interactive interface, a customer would select a diamond according to its shape (round, heart, square, and oval) and quality (color, clarity, cut, and carat weight). Then the customer can design their own diamond ring from different combinations of ring mountings using different gold tone (9 K, 14 K, 18 K, 24 K, and platinum). They can also engrave a short message at the rim of the ring. Such options are appreciated by both ordinary and VIP members because they can then design their final products based on their own style and preference. It is because buying luxury products like jewelry usually have high expectation on the product that fits the taste and style of a customer. Hence, product customization is very essential leading to customer satisfaction.

From our analyses, service customization has a positive impact on the satisfaction level for ordinary members ($\beta = 0.208^{***}$) and for VIP members ($\beta = 0.138^*$). In this online jewelry company, members usually received customized treatments according to their needs and requests. This arrangement proves that service customization is effective for inducing customer satisfaction.

With respect to the control variable, perceived value has also significant impact on customer satisfaction for ordinary members (0.681^{***}) and VIP members (0.631^{***}). In China, online shoppers are very concerned about “value for money”. And they always compare prices of similar products and services from different online stores. Once they achieve searching and acquiring a product with a reasonable price, they will feel satisfied.

In terms of contributions, this study empirically supports the theoretical model for customization strategies for an online business. The current research confirms the impact of the four customization perspectives on satisfaction. The findings suggest that customers need information from a Website. Product customization, however, has most impacts on satisfaction. In addition, service customization, which would influence the customer relationship, is also important to customers. This study represents an important step toward developing a theoretical understanding of the impact of customization strategy. The results also provide insights for online stores to devise more effective buyer-centric strategies.

6. Limitations and Conclusion

As it is the case with all empirical research, this investigation has several limitations. The cross-sectional research design dictated that all measurement items were collected. This research method may not fully capture the dynamics of the influence on online business. This constraint limits the extent to which causality can be inferred. To address the above issues, future research should consider employing multiple methods and longitudinal research designs. A longitudinal study combining qualitative and quantitative data would enable a process-oriented perspective that cannot be achieved using a variance-based approach, such as the one employed here.

In addition, our results may not be able to generalize to those in dissimilar institutional contexts. The online jewelry business in China is still emerging, and is on luxury product stressing on personal taste and style. Extending our findings to other online businesses such as 3C sites and apparel business, or business operating in different institutional and cultural environments should be taken in cautions.

In sum, this study investigates the impacts of customizations on customer satisfaction in an online jewelry business and observes the differences between the two groups of customers (ordinary and VIP members). Our framework is testified using the online jewelry store in China. It is an expanding market and gaining widespread popularity among high-income earners. Our findings confirm that information customization, product customization and service customization have significant impacts. Nevertheless, transaction customization does not contribute much to customer satisfaction. It is due to the fact that the online jewelry company mainly relies on some renowned third party logistic and payment service providers for handling a transaction. Moreover, service customization, which would strengthen the customer relationship, appears to be an effective means for online luxury market in China. Our findings also show differences between ordinary and VIP members. Online stores should consider how their platforms would facilitate different types of members in these four perspectives.

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Food Risk Management and Sustainable Development

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Abstract

For several years, the food industry sets up its own systems of controls and risk management to insure the healthiness of the products which it puts in market and as the last years were marked by the deep change of behavioural companies towards the natural, resource management, and the environment-friendlier adaptation of policies. The majority of these food-processing companies favored the introduction of methodologies of risk management in a concept of sustainable development which aims at expressing the access to a quality food supply, while contributing to the social and economic long-term development and also to protect the environment for the future generations. The integration of the idea of durability in the food processing industry by the implementation of a common system of management of the risks according to the food codex and by means of the method HACCP (Hazard Analysis and Critical Control points) aims at ensuring a better quality of life through the implementation of actions centered on health, by the control of the food chains. Our contribution, which becomes integrated into context, consists in bringing to light the factor health as a pillar into interface with the other themes to know the social, the economy and the environment.

Keywords

Sustainable Development, HACCP, Food Industry, Risk Management

1. Introduction

The food industry sector has become aware of the specific risks generated by this type of installation and its impact on the population health, which has raised a number of questions related to the management system which can provide information reliable on the safety and quality of the products coming to the consumers. All food can be contaminated in different ways and at levels that can cause disease more or less severe (such as, for example di-

gestive and nervous disorders, fever, vomiting, abortions, injuries, choking...), and can even cause death [1]. These risks of contamination exist in every company that manufactures sells or transports food. They can occur at every link in the chain representing the succession of the stages through which products move from their entry to the exit of the company [2]. The management of the food security consists to acting as a barrier for the defective components and the imperfect finished goods. A reception control for the purchased materials, inspections during the manufacture and verification of the finished products constitute the classical phase of the management of the safety and quality of food [3]. In the food sector the Codex Alimentarius Commission creates the FAO, and the WHO which was founded in 1962. There are also other regulatory references such as ISO 9000, 9001, 9004 and ISO 22000, which all of them have a common objective and that is the control of risks in this kind of sectors [4].

The food security has undergone a considerable development with the implementation of HACCP (Hazard Analysis and Critical Control Point) system, which is a systematic approach which aims to identify, evaluate and control the physical, chemical and biological risks along the whole production process [5], and it has therefore become the tool of control of the food hazards [6], the HACCP constitutes a reference base to the food safety, it provides a systematic method for analyzing the food processes, identifying potential risks and specifying their critical control point (CCP), to avoid the distribution of unsafe food to consumers [7].

Large part of humanity is faced with serious threats because of the food conditions are not in their favor. Confronted with such threats, we have to look for means to permanently ensure food safety and preserve the natural capital which conditions it. Generally, the decisions are difficult to take for various reasons, some of which are political considerations, social values, economic problems and legal issues [8]. But it is still science which is the most important element in decision-making for food risks assessment. It is for these reasons that the management aspect of food risks is considered as essential in the policy of food safety based on rigorous scientific criteria. So, the innovative integration of a sustainable development approach will be made by progressive actions using the results of a management system through the HACCP tool whose opportunities will [9]:

- Allow risk management using control procedures which have been implemented in health, food safety, environment, and working conditions;
- Help elaborate a common and progressive working document which deals with sanitary safety problems while suggesting a coordinated approach.

In this paper we try to overcome by introducing an original methodological approach which demonstrated two research axes:

- The first one was centered on the demonstration of the interest of the HACCP system implementation so as to provide the various companies with an efficient tool which evaluates and masters the dangers threatening food healthiness;
- The second part of the work helped establish an integration framework of this self control system in a policy of sustainable development, which aims at preventing the development of serious pathologies with nutritional constituent so as to ensure the durability of its activities, and which constitutes an innovation tool for the food-processing industry.

During this work, we present the following points and which will be the base of integration of our approach:

- The food industry on the way of durability;
- The Risk management by the HACCP system;
- The importance of the HACCP system for a sustainable development.

2. The Food Industry on the Way of the Durability

The World Conference on Environment and Development Rio De Janeiro 1992 granted a wide place to sustainable development and food safety. *“Food safety is assured when all the persons have at all moments the physical and economical average to get food stuffs in safe and nourishing quantities to cover their food needs and let them lead an active and healthy life”* [10]. So, durability means maintaining a certain degree of welfare for all persons that will not deteriorate through time. Therefore, the concept of sustainable development gives a new input to the food industry in the sense that it helps integrate the specific constraint of sustainable development in rational management [11]: Resources, respect of the environment, and reflection on the use of biotechnologies.

The biological component of the production of food stuffs is directly related to the reflection on the sustainable development of these industries. As an example, we can quote the recent public debates on genetically modified organisms, on diseases caused by food, on the environmental issues related to breeding and fishing, on north-south commercial exchanges, on public policies of resources management and markets support.

The objectives of food safety in the sustainable development policy are multiple. The most remarkable ones are [12]:

- Support to organizations and communities in the development and to organizations dedicated to education and awareness in order to improve the living conditions of the populations;
- Implementation and management of programs of production, distribution and access to food;
- Development of tools and participative methods in the field of food safety management and environmental protection;
- Food as a constituent of the right to live: consider food safety with development policies, that is, taking into account the interactions with the socio cultural and the process of governance (principle of balance between economic growth, social development and environmental protection).

In this study, we tried to make an investigation on the question relative to the sustainable development and to see sound degrees of integration in certain food-processing industries, and we ended in the following results: **Figure 1** and **Figure 2**.

3. The Risk Management by the HACCP System

The term “hazard analysis and critical control point (HACCP)” has been progressively recognized as a cost-effective procedure for ensuring food safety. Today, this methodology is internationally accepted as an effective tool to deal with safety hazards which may arise in the food production process [13]. Since the adoption of the Codex Alimentarius “guidelines for the application of the hazard analysis and critical point (HACCP) systems” and subsequent revision “hazard analysis and critical control point system and guidelines for its application”, the use of its seven application has become mandatory prerequisites in the food worldwide production chain [14], in order to prevent the occurrence of food safety hazards to final customers. For reinforcing public health security it has been urged the implementation of full HACCP in all food businesses [15].

The proposed principles are different from those of the Codex and no mention is made of the need for normal HACCP plans [16].

HACCP identifies risks in the production processes that can lead to unsafe products, and designs measurements to reduce these risks to acceptable levels. HACCP is designed for application in all links of the food chain, HACCP involves seven principles [17]:

- Analyze hazard (biological, chemical or physical);
- Identify critical control points (these are points in a food production at which the potential hazard can be controlled or eliminated);
- Establish preventive measures with critical limits for each control points;
- Establish procedures to monitors the critical control points;
- Establish corrective actions to be taken when monitoring shows that a critical limit has not been met;
- Establish procedures to verify that the system is working properly;
- Establish effective recordkeeping to document the HACCP system.

In the management of food risks, critical control point huge system step has been made with the application of from HACCP implementation helps not only to identify the risks and control them and especially reinforce the self control of the food-processing companies.

In this context, the role of the governments is to encourage the industries and help them adopt this system which helps: to analyze the risks which can occur, to describe critical points and their limits and to supervise and check the efficiency of the HACCP system.

Of course, the HACCP system is specific to each company where each case constitutes a particular study. Consequently, its implementation depends on the company’s decision. Furthermore, the HACCP system uses specific assistance tools. For example, for the determination of the CCP, we use the tool “tree of decision” whose elaboration is made thanks to a set of questions related to every risk and to every stage of the process, including the reception and the processing of raw materials.

4. The Importance of the HACCP System for a Sustainable Development

The management policy of food safety is an approach to sustainable development which mainly aims at gathering data based on scientific criteria while respecting the essential principles related to food safety. The latter is largely taken into account by the Codex Alimentarius which is composed of food standards and practical codes giving guidelines and recommendations on food security and food security management systems on the model

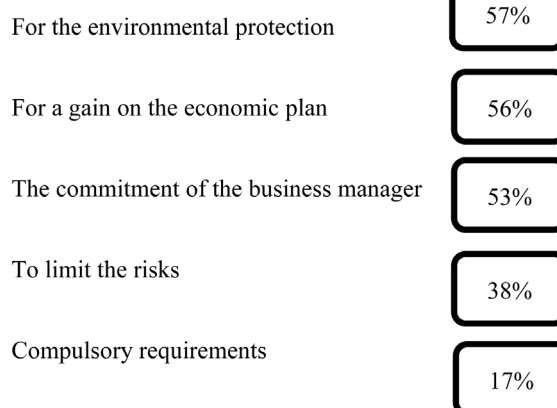
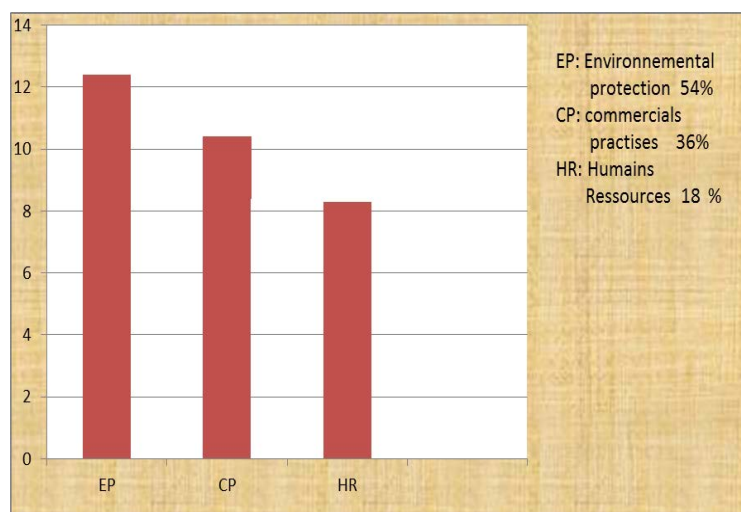


Figure 1. Why would you apply the sustainable development in your company?



Figures 2. In the following domains would you build up actions connected to the sustainable development?

of the HACCP system which is an instrument intended to assess hazards and to establish systems of control centered on prevention instead of calling upon procedures of a posteriori control of the finished product several works were conducted in this domain to show the importance of the integration of the sustainable development in management practices [18]-[21].

In practice, and for reasons of efficiency, food safety should integrate, in its management, requirements for sustainable development whose objective is to offer a product of quality while respecting the principle of balance between economic growth, social development and environmental protection [22].

Companies must then take steps by adopting plans and measures aiming at the improvement of the environmental profile of their activity (inputs, waste) or of their products (current energy consumption, management of life cycle) as well as the consideration of the social factor [23] interfering directly or indirectly in these activities (see Figure 3).

5. Stakes in the Integration of the HACCP for a Sustainable Development Policy

We note, after the application of the step HACCP system, that the most propagated risk is the presence of pathogenic bacteria which can have harmful effects on the consumers. The application of this approach has determined the parameters on which it is necessary to act (CCP) and the control measures, thus guaranteeing the effi-

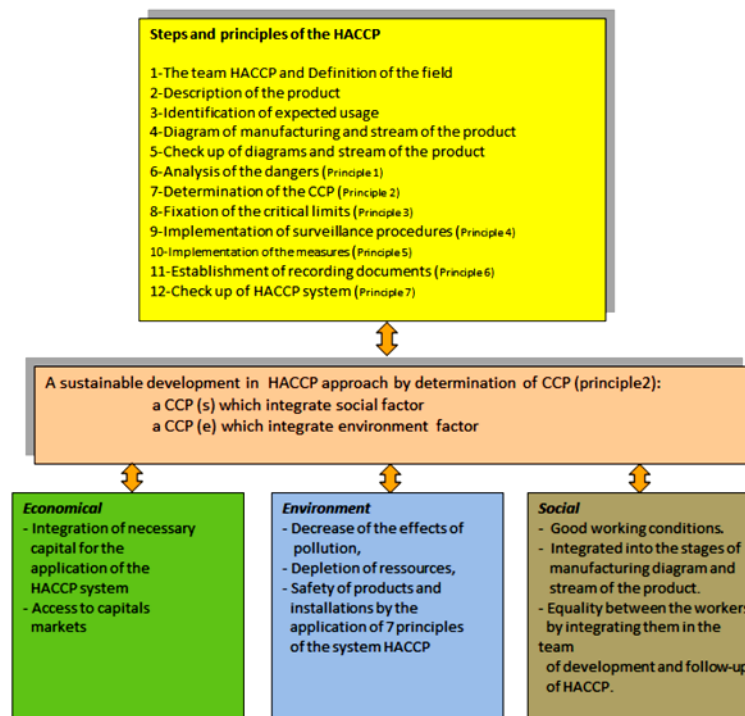


Figure 3. Integration of HACCP system in sustainable development steps.

ciency of preventive measures and reducing the dependence on the inspections of finished products.

The HACCP system can be applied all along the food chain, from the primary producer up to the consumer (on the whole life cycle of products), and it can also improve the sanitary safety of the food. The HACCP system allows, on the other hand, a better use of the energetic and economic resources [24].

So it comes at the forefront for its integration in a sustainable development policy which will be profitable to the industries working in the food processing field because it will help guarantee a long-lasting consumption by the design of appropriate products and services which require less energy and resources and which do not present any danger [25].

During the implementation of the HACCP system, we drew up a plan grouping together the main stakes in the sustainable development which must be considered by these industries (see **Figure 4**).

The general aims of this figure is to identify the key aspects (social, environment, economical) in the sustainability field in order to set up an integrated method, which will help Companies to develop a policy of integration with regard to their activities. In this context, the objective of this figure consists in bringing to light the health factor as a pillar in this approach of sustainable development while integrating into the interface the other themes, namely the social and the economic factors.

■ Social

- Sanitary quality by traceability actions and the results of the HACCP;
- Training of professional staff;
- Communication and information about the obtained results;
- Insure food quality through quality labeling;
- Ameliorate the working conditions using ergonomics and studies about the medium hygiene;
- Be economically responsible of buying for products from convenience stores.

■ Environment

- Decrease water and energy consumption by professional staff;
- Use cleaning equipment's with weak and energy consumption;
- Decrease raw material consumption by the amelioration of food consumption systems and fight against all kinds of waste;
- Limit the costs by the actions of energy and raw material saving.

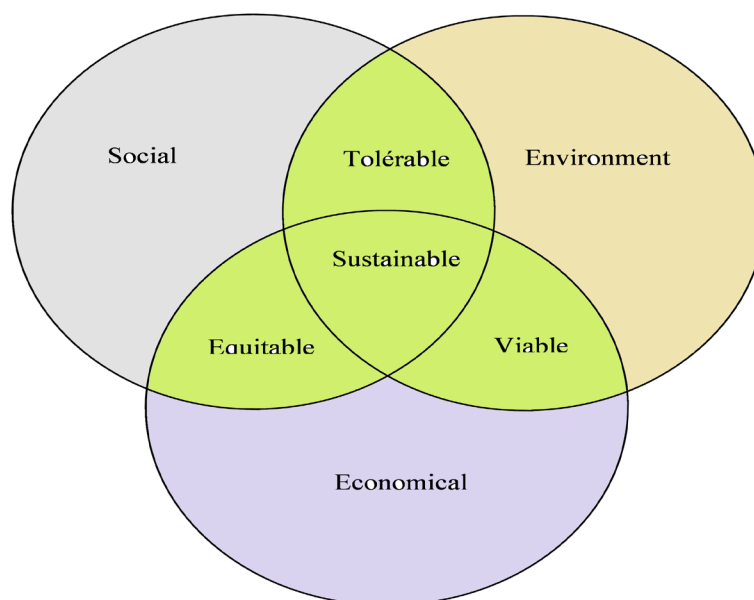


Figure 4. Main stakes of the sustainable development in food industry.

■ Economical

- Be economically responsible of buying for products from convenience stores;
- Establish confidence between supplier, customers and consumers.

6. Conclusions

Food Safety hazards may be assessed and appear at a stage of food chain “from farm to fork”, and it is the objective of the new international standard ISO 22000-2005 “food safety management systems requirements for any organization” in the food chain “ISO.2005”.

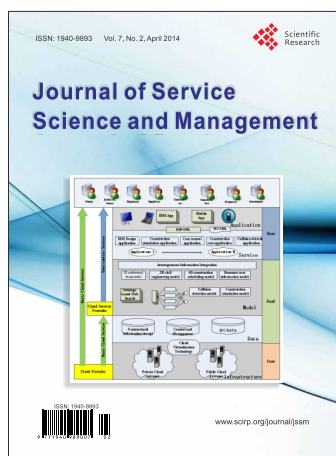
This new standard dedicated to the food safety management, should supply a precious complement in the approach HACCP. Its presentation is a guide for the identification, and the evaluation and the maîtrise of the sanitary risks are applicable to all the stages of food chains. His requirements concern at the same time the conditions of production and the quality of products, and his executive is the same of the norms ISO9001 or 14001, what permit a global approach (QSE), ells conferment thus an ethical approach in the activities, the result (of an awareness of the imperatives of a sustainable development, in the implications important for the environmental and economic, social future of our systems.

As far as food security is concerned, the HACCP approach dispyte all inconveniences. This approach still remains as one of the most applicable, and also it is considered as the most appropriate. The integration of a food company in a sustainable development optic, through this work, we project to associate and combine other main and tools with HACCP particularly ACV product, for a innovative approach to encircle better the problem.

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