An Adoption of Semantic Web from the Perspective of Technology Innovation: A Qualitative Research Approach

Joo, Jaehun

Professor of Information Management Department, College of Business and Tourism, Dongguk University, Gyeongju, Gyeongbuk, 780-714, South Korea

e-mail: givej@dongguk.ac.kr

Abstract

What factors affect the adoption and diffusion of Semantic Web innovation? This paper answers this question using multiple case studies. The case study as a qualitative approach is appropriate to achieve this, because the Semantic Web is at the early introduction stage. Data was gathered from seven out of nine organizations adopting the Semantic Web in Korea. Semi-structured interviews were used to collect data. Three factors affecting adoption of the Semantic Web were identified. The first factor is demand pull including requirements for solving search and integration problems of the existing systems and for creating new services. Second, environmental conduciveness, potential business value, government sponsorship programs, and active roles of suppliers affect the adoption of the Semantic Web from the perspective of technology push. Finally, absorptive capacity is an important role of the adoption. Four propositions are derived from this case study.

Keywords: Technology Innovation, Adoption of Innovation, Semantic Web, Ontology, Diffusion of Innovation, Case Study, Qualitative Research

1. Introduction

According to IT (information technology) innovation theory, organizational innovation depends on IT innovation and has a direct influence on its performance and success (Swanson, 1994). An IT or IS innovation can be defined as the creation or new organizational application of digital computer and communication technologies (Lyytinen and Rose, 2003). Lyytinen and Rose (2003) consider Internet computing as a disruptive innovation that offers subsequent pervasive and radical impact on development processes and their outcomes. Semantic Web as an extension of current Web is also technology innovation enabling organizations to overcome limitations of today's Web.

How should organizations adopt the Semantic Web? What factors affect adoption of the Semantic Web in organizations? Most studies on adoption and diffusion of innovation use empirical analysis as a quantitative research methodology in the post-implementation stage. There is criticism that the positivist requiring theoretical rigor can sacrifice relevance to practice (Bharadwaj, 2000). Rapid advances in technology require studies relevant to practice. In particular, it is realistically impossible to conduct an empirical study on factors affecting adoption of the Semantic Web because the Semantic Web is in its infancy. However, in an early stage of introduction of the Semantic Web, it is necessary to give some guidelines for adoption and diffusion of the technology innovation to practitioners. Thus, the purpose of this study is to present a model of adoption and diffusion of the Semantic Web and to offer propositions as guidelines for successful adoption through multiple case studies.

This paper is organized as follows: section 2 reviews the Semantic Web and related studies. Section 3 proposes a new adoption model of the Semantic Web innovation; it lists four propositions that can be considered as guidelines to theorists or practitioners. The final section draws conclusion.

2. Semantic Web Technology Innovation and Related Studies

2.1 Semantic Web Technology Innovation

Lyytinen and Rose (2003) classified IT innovations in three types: systems development innovations, service innovations, and IT base innovations. Systems development innovations involve changes in system development processes and correspond to Swanson's Type I innovation (Swanson, 1994). Service innovations include use of IT to support the administrative core of the organization and also to affect either business functions or core business processes. This compares Swanson's Types II and III. Finally, they distinguish IT base innovations from Type I and suggest that the three sets of innovation are mutually dependent in that an innovation in one type may spawn innovations in others. They consider Internet computing as both an IT base innovation and a disruptive IT innovation.

The Semantic Web can be considered an IT base innovation as described by Lyytinen and Rose (2003) and an IT technological process innovation classified as Type I by Swanson (1994).

The Semantic Web may contribute to organizational performance or business value through two paths as shown in Fig. 1. First, business value is derived from the Semantic Web when the Semantic Web

incorporates or supports Web Services as a Type I innovation. Second, the Semantic Web generates business value by enabling knowledge management systems as Type II innovation or ERP (Enterprise Resource Planning) as Type III innovation to overcome barriers or to improve services.

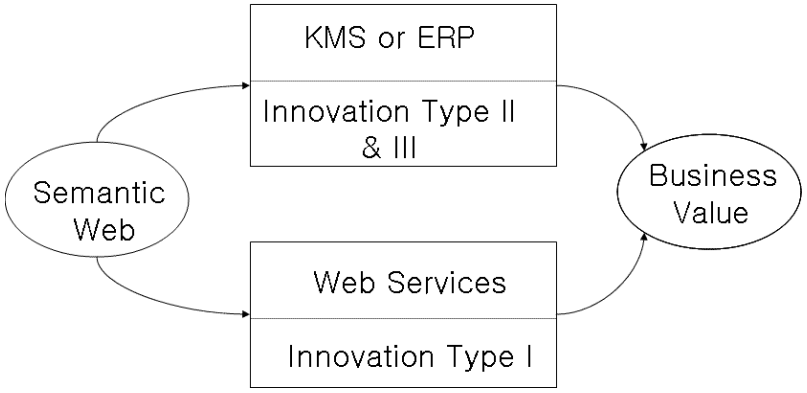

Fig. 1. Relationships among Semantic Web, innovation type, and business value

Two characteristics of Semantic Web technology are summarized as the potential to reduce information overload and enable semantic integration, using capabilities such as semantics and machine-processability.

All resources in the Semantic Web are represented in RDF (Resource Description Framework) as metadata. This representation method makes it possible for users to query and get answers, as if they are using database management systems. The Semantic Web also supports RDFS (RFD Schema) and ontology that enables semantic analysis on vocabularies contained in query and domains as well as syntactic analysis. The Semantic Web can provide accurate knowledge suitable to users. The Semantic Web also can offer context-aware knowledge to users because ontology languages, such as OWL (Web Ontology Language), support reasoning functions and domain knowledge. The inference function and context-aware capability will enable the systems based on Semantic Web to enhance the ability to search knowledge suited to users. Internal or external documents of organizations and Web resources can be represented as a resource in RDF. A resource of RDF, a knowledge object, can be searched with an independent knowledge unit as a user searches a document in document management systems. Furthermore, a specific part or sentence of a Web page or a part of a document may be represented as a knowledge object. This capability allows the systems based on Semantic Web to search for a knowledge object unit rather than a document unit.

The three types of integration are data, application and process (Giachetti, 2004). The goal of data integration is data sharing where different systems exchange data with each other. The goal of application integration is to achieve interoperability between systems. The obstacles of integration arise from syntactic and semantic heterogeneity between different information systems or applications (Noy et al., 2005; Uschold and Gruninger, 2004). Until recently, the approaches for providing interoperability include standardization and middleware or mediators as well as enterprise application integration (EAI). Although the traditional integration approaches such as middleware and standardization easily integrate structured data extracted from heterogeneous databases, they have limitations when integrating unstructured data or knowledge from sources such as HTML (HyperText Markup Language), word processor files, and spreadsheet files. In the integration approach based on the Semantic Web, the software agents understand the meanings of the terms and automatically process them by exploiting the RDF and ontologies. Since W3C adopted XML (eXtensible Markup Language) as the Web document standard, XML has been widely used to ensure interoperability among heterogeneous systems (Uschold and Gruninger, 2004). The Semantic Web, RDF, RDFS, and OWL follow XML-based syntax. In the Semantic Web, a software agent can access heterogeneous systems and provide knowledge and information suitable to users. The Semantic Web enables software agents to extract some parts of the related knowledge from different resources and to automatically aggregate them without user intervention.

2.2 Related studies

Research on the Semantic Web can be classified into four areas: developing infrastructure and architecture, killer applications, business management issues, and other social issues. Until recently, most research has dealt with technical issues related to architecture design and building infrastructure for information systems based on the Semantic Web (D'Aquin et al., 2005; Davies et al., 2003; Edgington et al., 2004; Lee et al., 2005; Maedche et al., 2003; Noy et al., 2001). For example, D'Aquin et al. (2005) presented a system architecture based on the Semantic Web in the medical field of oncology. The systems provide knowledge representation, reasoning and visual editing used in treatment of cancer patients.

As Orlikowski and Iacono (2001) pointed out, it is necessary to study the complex ensemble of people, culture, and technology embedded in social contexts as well as at a specific organizational level. According to Hevner et al.'s (2004) dichotomy of research on management information systems, studies of the infrastructure or architecture and killer applications refer to design science while other issues are behavioral science. The former is more aligned to technology push than the latter. In the early introduction stage of the Semantic Web, research regarding demand pull enables developers to reflect the user or market needs in technology development or its applications. This can contribute to improving the IT investment performance. Most behavioral science studies reflecting demand pull have been conducted at the post-adoption stage of a specific technology. A study of the Semantic Web, as an IT innovation dealing with business issues together in the perspective of demand pull, is important, especially in the environment of rapid IT development. However, no research addresses a managerial issue such as the topics dealt in this paper.

3. Research Design and Analysis

It is not easy to gather data using survey questionnaire for an empirical study because the Semantic Web is in an early stage of adoption. In general, case study method is suited to answer how and why questions through in-depth interviews in early research stage or theory-building (Benbasat et al., 1987). The researcher conducted multiple case studies to avoid the limitation of single case study being criticized as lacking generalizability.

3.1 Sampling and Data Collection

Information about the adoption of Semantic Web was collected from a variety of sources, prior to select organizations suitable to study. These include Internet searches, newspapers, journals, proceedings of conferences and other documents. Nine organizations shown in Table 1 have been offering services entailing information systems based on Semantic Web, as of October, 2007. The organizations introduced the Semantic Web in 2005 to 2007. The primary objectives or motives are to offer semantic search services or integrated intelligent services.

Table 1: Organization profiles

Organization	Year of initial service	Primary objective	Type of information systems
A	2006	Intelligent and personalized services on mobile devices	Telecommunication Systems
B	2007	Search service on Internet Web	Web search systems
C	2005	Integrated search service	Korea Online e-Procurement Systems
D	2007	Integrated search service	Research Information Network
E	2007	Intelligent recommendation service	Recommendation systems of reviewers
F	2007	Information search & visualization	Public library information systems
G	2007	Integrated search service	Intranet and management information systems
H	2007	Integrated search service	Culture content & information systems
I	2006	Knowledge management service	Knowledge management systems

Nine interviewees from seven of nine organizations (the exceptions being H and I) responded to questions about adoption and diffusion of Semantic Web. The researcher conducted semi-structured interviews and interviews were face-to-face. Interviews were recorded, transcribed in Korean and translated into English prior to analysis. 91 pages of transcripts were obtained from 5 hours interviews. Triangulation of evidence was achieved by examining each organization website and various documents, such as brochures and white papers.

3.2 Analysis and Adoption Model

Data analysis is important to overcome the drawbacks of qualitative research. The researcher used the data analysis spiral presented by Creswell (1998). First, the researcher read the transcripts several times and underlined core words, phrases, or sentences. Then, data analysis used the procedure of open coding, in which the researcher forms initial categories of information about the phenomenon being studied by segmenting information. The research draft was sent to the interviewees. Five interviewees gave feedback expressing their views about classifications, categories, or research findings.

Improvements of existing information systems

Table 2: Interview contents: Limitations of the existing systems and service improvements

Categories	Examples of interviews
Overcoming and improvements of search and integration limitations	"My organization was in a terrible vicious circle where one problem gave rise to another. This led to employees' inconvenience, and in turn big problems in search systems resulted in manual searching along with low productivity. If I need to look for something, I just find it more convenient to search for it off-line; My organization needs something with good search service. I end up adopting search systems based on ontology."
	"As heterogeneous catalog standards were used in e-marketplaces, some difficulties existed in the connection between the current public e-procurement system and B2B e-commerce systems. As a way to solve this problem, I have adopted database systems based on ontology."
	"After ERP of SAP was established along with one single access point in the groupware with modules such as CRM, and eHRM, an integrated search service was required as a portal concept."
Improvements of other services	"Since my company is engaged in mobile phone service with revenue models, it does provide various kinds of services you can name. But those services were not so popular as I had expected, and so I tried to identify the possible causes for the failure. The biggest cause turned out to be the fact that its display was not as big as the one on desktop computers. The display is what matters most. The best technical solutions available for those listed problems were marked as personalization and intellectualization; and so I decided to adopt the Semantic Web technologies."
	"The basic motivation for adopting Semantic Web was to improve the existing services. The amount of information has increased considerably, but there is still lack of information in certain categories. The quality of information is now more appreciated than ever before. The volume of search results does not matter, but the significance is information customized for the user."
	"When I wondered how to utilize data and to improve services, I realized that Semantic Web would be the best alternative available and that's why Semantic Web was adopted."
Other service improvements	"My company had been trying to provide wireless data services with personalization. I mean, via current user devices, it was realistically impossible to show a lot of information within the limited displays and customers also found it too difficult to locate the services they wanted."

* B2B: Business to Business, ERP: Enterprise Resource Planning, CRM: Customer Relationship Planning, eHRM: Electronic Human Resource Management

Requirements for new services

Table 3: Interview contents: requirements of new services

Categories	Examples
New services	"I have studied how to enable so-called intelligent recommendation services and analyzed the technology trends so far. In the meantime, I have pursued the services as a killer application of the Semantic Web. "
	"I needed to store subscriber information to enable personalized and intelligent services. I got to understand that it was necessary to use ontology and the Semantic Web enables those services."
	"I was wondering, 'Can I come up with some analytical system based on simple existing relational database? Can I just make some recommendations by analyzing relational database? Maybe can I figure out some methods to make automatic recommendations by making it more intelligent?' I thought ontology technology and some other technologies had possibilities, or I could go this way or another…"
Business models	"I think it is highly important to devise a business model first. Users must agree to the marketability of such service models and proliferation must follow, and then other companies would be willing to adopt them."

Expansion of conducive environment

Table 4: Interview contents: expansion of conducive environment

Categories	Examples
Expansion of conducive environment / Expert competency	"The domestic conducive environment was not quite ready yet to make it happen. The supplier's technology and their system analysis and development abilities were not close to full-fledged. Well, sorry to say this, but there was no expanded conducive infrastructure at all. More demand must proceed to induce more supply; I simply don't have demand for it, whatsoever. There have not been so many users just yet."
Reference models and uncertainty	"I was basically willing to contribute to some data or Web services by utilizing Semantic Web, but I realized the timing is not just yet right to reach such stage. In fact, the Semantic Web is too idealistic. I should have approached step-by-step toward the idealistic big picture. I felt I was way too ahead of the market when I tried to proceed with our business"
	"It was ultimately for actual service, but there were few models to provide service. So, thing was, I couldn't find any successful cases to refer to this particular business."
	"Could this really work? I thought this way, and actually, I reported to my boss that utilizing such engines based on ontology might be pretty erroneous and with so much trouble it might be highly implausible to make it a real business. That's what I said. It was just a year ago; it was not optimistic at all back then. I had my own doubts if it could really work."
Maturity of technology	"Querying was limited for hundreds of millions, fewer than one billion. More than that means too much time to query and impossible to do it in real time. I just can't put all them in infinitely. Too problematic to handle large quantities." "In a circumstance with specific time restrictions, the time to establish ontology could be really time-consuming. Unless I specify a specific domain for it, it is a technology with no beginning and no end."

Potential value

Table 5: Interview contents: potential value

Categories	Examples
Service improvements and utilization	"Once I adopt Semantic Web and intelligent and personalized services are possible, I will probably have better services than with the existing technologies. That's what I had in my mind and why I got started."
	"Comparing the existing technologies and Semantic Web, I think, the former could achieve as little as 50% while the latter will enable us to achieve up to 70 ~ 80%"
	"I see that this particular technology is worth utilizing and so its utilization is abundant, but it can't be the answer to all the problems. Even if this technology is applicable to certain areas, but it is not possible to apply it to all the areas."
	"Once a new technology is released, a lot of reviews are made. But its adoption is a totally different issue. Introducing such technologies with limited financial resources; great economic feasibility must be proved."

Government sponsorship and proactive roles of the relevant agencies

Table 6: Interview contents: government sponsorship and proactive roles of the relevant agencies

Categories	Examples
Government sponsorship	"The project for intelligent service was done through government sponsorship. Developing intelligent systems is part of national policy projects. Since the existing technologies have failed to offer such services, I need to experiment more with ontology and Semantic Web technologies."
	"As I was interested in analyzing the technology trends, I got to participate in the national policy project and took part in introducing it."
Relevant agencies	"As working groups, I attend seminars held by Web Korea Forum, Semtech, ISWC, and ASWC."

Absorptive capacity

Table 7: Interview contents: absorptive capacity

Categories	Examples
Supporting Systems	"External experts have recommended them and our staffs have shared new knowledge or information, and assessed if they were proper; that's how I got started the business."
	"My organization recommends that I attend academic seminars or workshops. My organization even assists in costs for business trips and other required expenditure."
	"We have a system now; the personnel department controls the number of subjects, after I apply for such and such subjects for the year."
	"In my company, there are three different research institutes and here I mainly involved in analyzing new technology trends."
	"It's like a top-down approach by which a person-in-charge makes a recommendation, the Information Promotion Committee considers it in terms of management objective and aggregates each recommendation into an education bundle."
Technology analysis competency	"It seems that people had this ambiguous feeling that adopting Semantic Web would guarantee something; so it was like a gold rush last year. From the viewpoint of a participating company, I was just bewildered by suppliers and other companies because of these environment and atmosphere. All these could lead to another problem, you know. After all, people are not ready for all these."
	"From the technical viewpoint, people should seriously consider if Semantic Web would be helpful for providing such services. However, they simply believe that their services might be better with Semantic Web. This is a wrong approach. They should first consider if the Semantic Web is appropriate for offering such services."
Manager's passions and support of CEO	"For instance, seminars are held by the Information Engineering Society, the Artificial Intelligence Research Society and so on. With initial interests in such areas and more contacts as well as meetings with presentations from companies or such organizations, I prepared business plan while checking on technical development levels of those people."
	"I just want to get as many opportunities as possible to learn more about them, but it was just not possible. I try to attend more academic workshops if I have chance."
	"I read a lot of papers and theses before planning for any business. I go to different seminars and meet with different business people for that matter.
	"When I developed a policy, I searched for cases of foreign countries and attended various workshops."
	"My organization should do it on the level of our internal departmental heads. I should gather some people who were even against our plan and talk with them. I had many meetings with them. In the beginning, I probably had a meeting at least once a month. The more frequently we met, the more positive they became, while becoming startled and convinced in the process."
	"CEO's technical understanding is not good enough, but he has rather good understanding in significance of good information and efficiency of management; so he was helpful in our adopting Semantic Web."
	"Once all these become social issues and directors and other people hear a lot from outside, I was first involved as part of research, not developing systems in 2006. And then, I was asked 'What is the research for?' So that's how I took part in the initial project."

Requirements for diffusion

Table 8: Interview contents: requirements for diffusion

Categories	Examples
Sharing a critical mass level of ontology	"The keywords by individual users are extremely various. Since the system does not have enough instances, and it can't afford to handle all the requests, users usually try searching one or two and get out of the web sites according to user statistics. The search quantity is extremely big, but since users' interests were not properly returned, I had difficulty in the diffusion of the service in those aspects. Even though better services with establishment of ontology are idealistic, there are not many cases to make many returns suitable to users' requests."
	"But from the viewpoints of survey respondents, it was very helpful. To maximize the

	helpfulness, I need to have more data stored in the systems in terms of quality as well as quantity."
	"It seems possible to develop ontology for each domain. Since nowadays we are in the era of Web 2.0, it is more important to share with each other and so it will be more useful in that aspect."
Budget	"I have to share the limited budget and resources, I now focus more on efficiency and economy. If I don't have any visible effects or demonstrable results after budget is allocated, then it's very difficult to secure any more the budget."
	"At least three years of stable budgets are required to help it grow to be an optimum scale and to get demonstrable results from that time on."
Visible effects (killer applications)	"Nowadays, I see that more demands occur, but at the same time I need more successful cases or reference models. In the areas of personalized services, ontology and Semantic Web are more applicable, but it is very difficult to develop intelligent and personalized systems up to the level where its effectiveness can be visible or demonstrable. After all, I need to develop ontology up to moderate levels by adjusting them."
	"The common opinion about it is that a killer application must be identified and emerged for various applications of this technology. Many people interested in Semantic Web need some killer applications. The Semantic Web will proliferate when it is highly successful in a certain area."
	"It is highly necessary to find the best business model of Semantic Web applications and to address a service where it can get all the public attention it deserves," "Find a killer application of the Semantic Web, demonstrate that at least it can survive in a particular area and become the best alternative." "Actualization of market; in order for the technologies to enjoy a long-term success, a good killer application must be identified."

Three factors affecting adoption of the Semantic Web were identified by analyzing the transcripts and aggregating categories through the process of reducing the data as shown in Figure 2 to Figure 7. The first factor is demand pull including requirements for solving search and integration problems of the existing systems and for creating new services. Second, environmental conduciveness, potential business value, government sponsorship programs, and proactive roles of suppliers affect the adoption of the Semantic Web from the perspective of technology push. Finally, absorptive capacity plays an important role in the adoption. The absorptive capacities include formal systems supporting or encouraging adoption of emerging technology, employees or team's competency analyzing technology characteristics, their passion or willingness to adopt successfully, and CEO support or active participation.

According to Zmud and Apple (1989), a stage model of technology diffusion consists of initiation, adoption and acceptance, adaptation, routinization, and infusion. Most cases in this study correspond to adoption and adaptation stages. Three factors were identified as determinants affecting successful routinization and infusion. The scope of services applying the Semantic Web must be not only reach critical mass, but ontologies must be also shared to be cost-effective. The budget to make further investment needs to enable the service to reach critical mass, and to achieve sustainable service. Finally, the projects that adopted the Semantic Web have to demonstrate positive results, such as service improvement, or productivity.

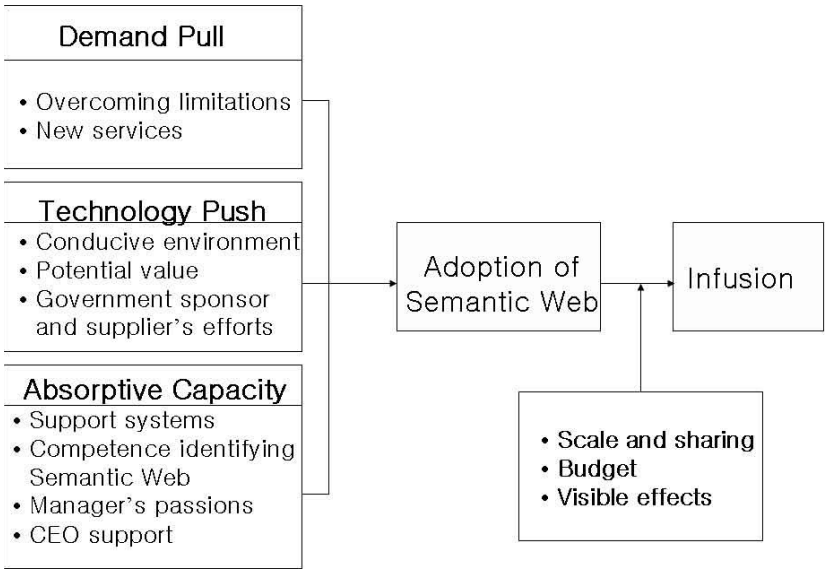

Fig. 2. Adoption model of the Semantic Web

The following propositions are derived from the adoption model following analysis of these case studies.

Proposition 1. The stronger the degree of perception of limitations of existing information systems, and requirements for service improvements and new services are, the more successfully the Semantic Web is adopted.

Proposition 2. Technology push such as government sponsorship programs, proactive activities of supplier-side organizations or associations, and a greater perception of potential business value from demand-side organizations is positively associated with successful adoption of the Semantic Web innovation.

Proposition 3. The absorptive capacities such as organizational formal support systems, officer's or manager's competency analyzing technology characteristics, their passion or willingness, and top management support are positively associated with successful adoption of the Semantic Web innovation.

Proposition 4. The post-adoption activities such as budget allocation, reaching critical mass, and sharing ontology to offer sustainable services are positively associated with successful routinization and infusion of the Semantic Web innovation.

4. Conclusion

In summary, three factors affect adoption of the Semantic Web. They are called demand pull, technology push, and absorptive capacity. The scope of services applying the Semantic Web, the budget to make further investment, demonstrable or remarkable benefits are important to diffuse the Semantic Web after its adoption.

Many organizations have tried to adopt the Semantic Web as a core technology of Web 2.0. Four factors influence adoption and diffusion of the Semantic Web. The four propositions can form a guideline for further research and implementation by practitioners.

Public organizations have been more active than private companies in incorporating the Semantic Web in their information systems. The reason is twofold. Most projects related to the Semantic Web were performed through government sponsorship. Many firms with exception only a few leading companies are waiting and seeing for adopting the Semantic Web. Further research is to analyze cases involving suppliers that develop the Semantic Web technologies, together with organizations that adopted the Semantic Web. Such research can contribute to providing a broad view of guidelines to diffusion of technology innovation and help to identify the gap between adopters and developers from the perspective of diffusion of technology innovation.

* References are available upon request.