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Constructing Ontology-based Exclusive Environmental Certification Systems

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Abstract

Since the 1970s, governments around the world have developed environmental regulations and environmental management system (EMSs). Public and private enterprises are obligated to comply with EMSs to prevent environmental pollution. After the International Organization of Standardization (ISO) published the ISO 14001 EMS in September 1996, environmental certification became a focus of attention for enterprises worldwide. Subsequently, various EMSs, such as the ISO 14064-1 Greenhouse Gas Emission Auditing System in 2006 and the ISO 50001 Energy Management System in 2011, have been developed. Governments can demand environmental certification to enforce compliance with environmental regulations. Furthermore, environmental certification can motivate enterprises to improve environmentally relevant practices, conserve energy, and lower costs. This study establishes an ontological knowledge model of shareable and reusable environmental certification index systems. According to this knowledge model, an environmental certification system, an environmental performance index system, and a leather-industry-exclusive environmental certification system were created using the Web Ontology Language (OWL) found in the Protégé platform. The relationship between the EMSs and the performance indices was then generalized to explain the certification systems and their attainable performance indices to enterprise owners. Thus, enterprise owners can select applicable EMSs according to this EMS ontology.

Keywords: ontology, environmental verification, environmental performance

1. Introduction

Since the 1970s, governments around the world have developed environmental regulations and environmental management systems (EMSs). Enterprises are required to comply with these EMSs to prevent environmental pollution. After the International Organization for Standardization (ISO) published the ISO 14001 EMS in September 1996, environmental certification became a focal point of attention for enterprises worldwide. Subsequently, other EMSs, such as the ISO 14064-1 Greenhouse Gas (GHG) Emission Auditing System (introduced in 2006) and the ISO 50001 Energy Management System (formulated in 2011), have been developed. Environmental certification can guarantee that enterprises comply with environmental regulations and can improve the natural environment, conserve energy, and lower costs which can be the green competitiveness of the firm. According to Olson (2008), advanced an enterprise-level green activity that leads to cost-down effectively and Siegel (2009) observed that green activity can promote a company's image to increase profitability.

The ISO and the aforementioned EMSs are briefly introduced as follows:

1.1 International Organization of Standardization (ISO)

The ISO is an international union that consists of national standards bodies from various countries. The preparatory work for establishing international standards is typically executed by the technical committees (TCs) of the ISO. The ISO has established several EMSs, such as the ISO 14001 EMS, the ISO 50001 Energy Management System, and the ISO 14064 GHG Emission Auditing System. Each EMS is formulated by a different TC. For example, the ISO 14001 EMS was formulated by Sub Committee 1 of ISO/TC207 in 1996.

1.2 ISO 14001 EMS

The ISO 14001 EMS, developed by the ISO in 1996, is an effective EMS aimed at helping enterprises achieve their environmental and economic goals. The requirements enforced in this EMS involve legal items and critical environmental considerations. This EMS calls for enterprises to develop and implement various environmental policies and goals. This EMS is applicable to all enterprises regardless of form and size. ISO 14001 requires that all enterprises develop various environmental policies and goals, procedures for attaining the policies, and necessary measures to improve their performance. This structure compels manufacturers to comply with environmental regulations and continuously improve the natural environment. In response to increasingly stringent environmental regulations, environmental problems caused by economic policies and other factors, and continuing pressure from environmental and relevant economic development groups, enterprises have continually focused on complying with environmental policies and regulating their environmental impacts. Compliant enterprises devote their activities, products, and services to achieve and confirm high levels of environmental performance. There was a research studies indicated that ISO 14001 implementation triggers a reduction in costs through reductions in the generation of wastes, energy savings, reutilization, or recycling of residues, reduced numbers of fines for regulatory violations (Jong, Paulraj, & Blome, 2013). The ISO 14001 standard proposes to improve the environmental performance of an organization by restructuring its strategic configuration, objectives, and targets, and also by manifesting itself in the company's production processes, applied technologies, and residue treatment procedures, among other areas.(Elise Soerger Zaro, Cláudio Soerger Zaro, Fernando Richartz, Altair Borgert, and Hans Michael Van Bellen, 2015)

1.3 ISO 50001 Energy Management System

The *ISO 50001 Energy Management System* was formulated by the ISO/PC 242 Energy Management TC in 2011 in response to global warming and climate changes. This EMS is aimed at prompting enterprises worldwide to spontaneously improve their energy efficiencies and establish the procedures and systems required to attain that goal. Because the proliferation of diverse environmental policies and regulations in each country can obstruct international trade, enterprises apply ISO 50001 to ensure consistent execution of energy-saving procedures in various national markets. Because the entire world faces increasing natural resource depletion and global warming, carbon reduction has become an unavoidable social responsibility for enterprises worldwide. EMSs provide a set of internationally approved energy-saving systems for enterprises to follow in their production and service procedures to reduce energy waste and carbon emissions.

1.4 ISO 14064-1 GHG Emission Auditing System

The ISO 14064-1 Greenhouse Gases Part 1: Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals, established by the ISO/TC207 Environmental Management TC in 2006, calls for enterprises to design, develop, manage, and report GHG examinations according to specific principles and requirements. The requirements listed in the EMS, including defining the upper limits of GHG emissions, quantifying GHG emissions and removals, and distinguishing the specific GHG management improvement measures and activities, are aimed at enforcing the responsibility allocation, quality management, reporting, and internal auditing of GHGs. If an organization clearly and consistently quantifies, supervises, reports, and verifies its GHG examinations and plans, its GHG emissions can be reduced and large quantities of GHGs can be removed. Research of Matsumura, E. M., Prakash, R. and Vera-Muñoz, S. C. (2014) indicated the reduction of the Greenhouse Gases and the value of the firm had the negative correlationship.

2. Research Motivations and Objectives

This study formulates an ontological knowledge model and establishes a shared and reusable environmental verification index system. On the basis of the proposed ontological knowledge model, an environmental certification system, an environmental performance index system, and a leather-industry-exclusive environmental certification system were created through the use of the Web Ontology Language (OWL) found in the Protégé platform. The relationships between the EMSs and the performance indices were generalized to help enterprise owners understand the certifications and the attainable performance indices. By using the proposed EMS ontology, each enterprise owner can select the EMSs that are most applicable for each individual enterprise.

Passing environmental certification is a basic requirement for any leather manufacturer that hopes to compete with other companies in the industry and acquire orders. Before entering sports-related international leather markets, a leather manufacturer must first acquire ISO 14001 EMS and Leather Working Group (LWG) environmental certificates to be qualified as a leather-supplying company. The LWG consists of world-renowned sports brands.

The requirements and standards vary with each brand. An ontological structure on the EMSs of the world-renowned brands was generated with OWL on the Protégé platform, and the requirements of each brand and guidance to certification were provided to leather manufacturers that propose to gain a foothold in the market.

In addition, the relationships between the EMSs and the performance indices were generalized to enable enterprises to select their desired EMSs according to the types of performance they aim to achieve. By earning environmental certification, enterprises can improve their levels of environmental efficiency and industrial competitiveness.

3. Research Methods

3.1 Introduction to Ontology

Ontology is defined as a clarified specification of a conceptual model for knowledge sharing, particularly between programs and humans（Gruber, 1993）. Ontology in the general sense is the philosophical study of the essences of entities that exist in nature; it involves a systematic description on the entities that exist in the real world, and it is not expressed in one specific language（Bunge, 1977）. Practical ontology holds that the real world is composed of multiple different domains, each of which can be known in terms of unique domain knowledge. Each domain consists of its relevant basic things, which can in turn be used to describe and construct the domain. The construction results can be preserved; constructed characteristics and relationships can be changed to achieve the reusable and shareable characteristics of the basic things（Guarino, 1995）.

Guarino (1998) revised Gruber's definition of ontology as a logical theory used to describe the intended meanings of a set of vocabulary items. To achieve this conceptualization, logical languages are used. Because of the limitations of the ontological commitment of these languages, appropriate intended models must be identified from these languages to explain the intended meanings of the vocabulary in the conceptualization（Guarino, 1998）. Generally, an ontology consists of the following five components（Michael et al., 2003）:

(1) Entities, also known as classes, concepts, or general things, which refer to the tangible and intangible things in a specific domain such as people, roles, and time.

(2) Instances, also known as particular things, which may include specific human beings. For example, Tim, Tom, and Kim are distinct instances of human beings.

(3) Attributes, also known as properties or property values, which are used to describe the characteristics and the possible range of an entity's characteristics such as color and weight.

(4) Relations, which describe the rules and relationships among entities or between entities and concepts.

(5) Constraints, which refer to the limitations and rules of an entity.

Fowling is an example: EMSs are an entity. Each individual EMS is an instance. For example, ISO 14001, ISO 50001, and ISO 14064-1 are different instances. Each EMS exhibits a unique attribute. ISO 14001 is intended to enforce environmental regulations; ISO 50001 is aimed at saving energy; ISO 14064-1 is intended to reduce carbon emissions through the examination of the GHG emissions of each enterprise. Each of these EMSs exhibits its own distinct requirements and goals, but all of them are related to one another. All ISO EMSs are employed to enforce legal regulations and continuously improve the environment. Figure 1 illustrates the ontological structure as described in this subsection.

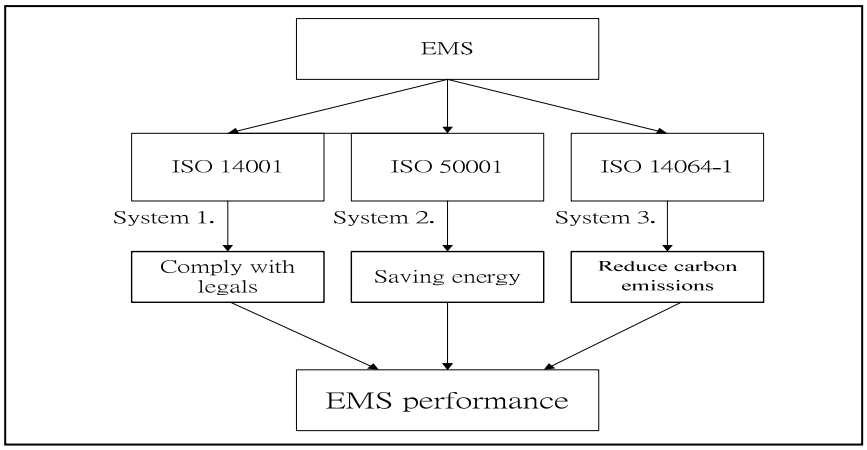

Figure 1. Ontological Structure of EMS

Nowadays, ontologies are used for making information explicit and allowing it to be shared. A good solution for improving data and knowledge management would be to create an ontology-based application that could properly manage all the organization's knowledge. Such a process would involve modeling this knowledge in an ontology.(Mari Carmen Suárez-Figueroa, Asunción Gómez-Pérez and Mariano Fernández-López, 2015) Ontology can well represent and reason about the domain knowledge, is proved to be very useful in the semantic retrieval. (Lijun Tang and Xu Chen, 2015) The Ontology can serve as a framework for the semantic standardization and it will contribute to a better exploitation. (Jesualdo Tomas Fernandez-Breis, Hirokazu Chiba, Maria del Carmen Legaz-Garcia and Ikuo Uchiyama, 2016)

3.2 Introduction to the Ontological Instrument: Protégé

Protégé, commonly simplified as "Protege," is an ontological editing and knowledge acquisition platform developed at Leland Stanford Junior University. It is open source software written in Java. Currently, Protégé is one of the most widely employed ontological editing platforms because of its exceptional design and abundant set of plug-in modules.

Protégé is used to edit ontological structures and knowledge bases. The interface of Protégé can be set up according to the needs of its users to assist them in adapting to the use of new languages. Protégé features a customizable data entry module to convert the contents of its internal representation to multiple text formats such as XML, RDF(S), OIL, DAML, DAML + OIL, and OWL. Although the basic form of Protégé is not equipped with a built-in reasoning tool, it exhibits strong extensibility; plugins can be installed to enable Protégé to perform special functions such as reasoning, inquiries, and XML conversions. Protégé provides an extensible independent platform environment for constructing and editing ontological structures and knowledge bases.

3.3 Constructing the Ontological Structure of the EMS

3.3.1 The Ontological Structure of the EMS

The ontological structure of the EMS was established through the use of OWL in Protégé as shown in Figure 2. The ontological structure consisted of three major parts, namely the green product certification system, the industrial environmental certification system, and the ISO-standard environmental certification system.

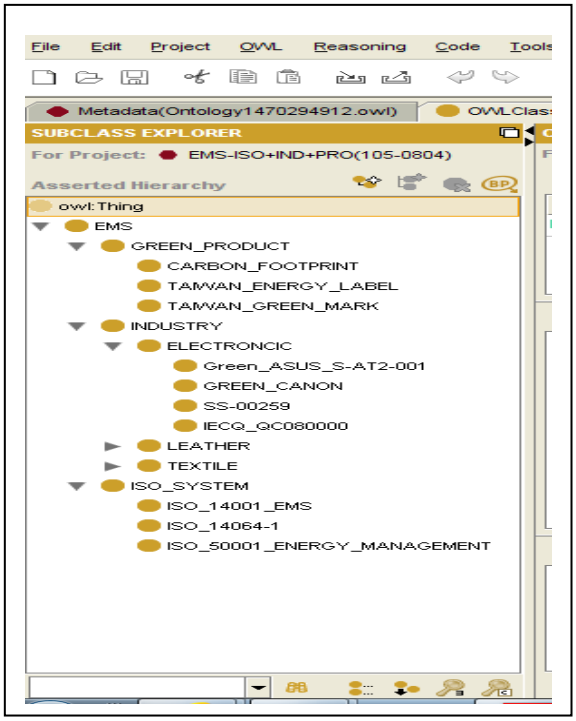

Figure 2. Ontological Structure of the EMS

3.3.2 The Ontological Structure of the Leather-industry-exclusive Certification System

The ontological structure of the leather-industry-exclusive certification system was established through the use of OWL found in Protégé (Figure 3). The first level of the system divides numerous world-renowned sports brands according to their geographical regions, namely the EU, Japan, and the U.S.A.. The second level lists the names of these brands and identifies their EMSs.

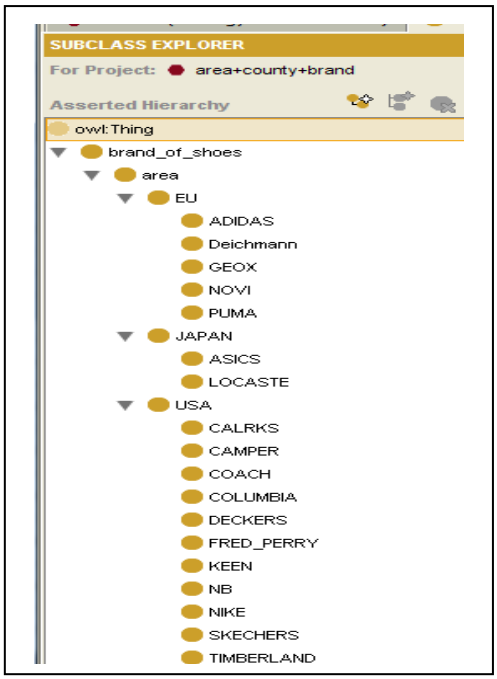

Figure 3. Ontological structure of the leather-industry-exclusive environmental certification system

3.3.3 The Ontological Structure of the Environmental Performance Certification System

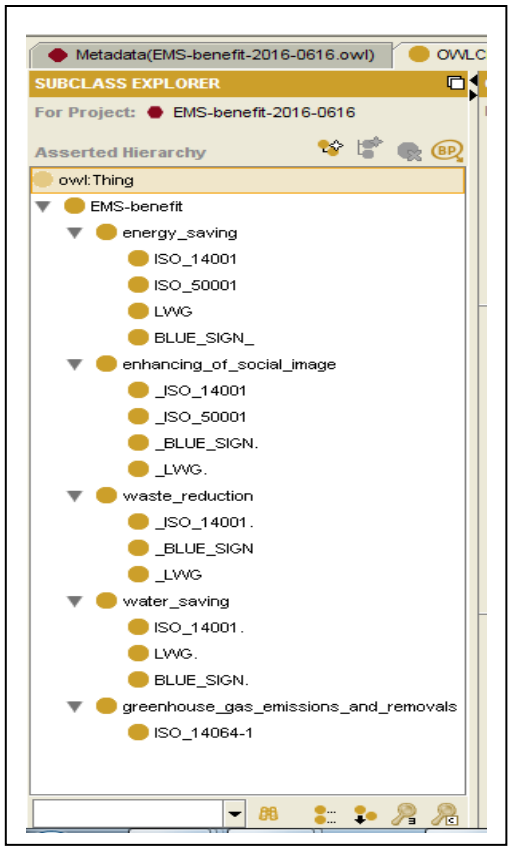

Figure 4. Ontological structure of the environmental performance certification system

The ontological structure of the environmental performance certification system was created through the use of OWL found in Protégé as shown in Figure 4. Each individual EMS was created to fulfill environmental performance indices such as conserving water and energy, managing restricted substances in creating green products, reducing wastes, and improving the reputations of enterprises.

4. Analysis Results and Discussion

4.1 Ontology-Based Exclusive Environmental Certification Systems

The ontological structures of the environmental certification systems were created through the use of the OWL in Protégé. Each EMS was categorized as an ISO-standard EMS, an industry-exclusive EMS, or a performance-based EMS. Figure 5 depicts the ontological structure of the EMSs.

The ISO-standard EMSs were the ISO 14001 EMS, ISO 50001 Energy Management System, and ISO 14064-1 GHG Emission Auditing System.

The industry-exclusive EMSs included the LWG standard for the leather industry, the Bluesign, Global Organic Textile, and Oeko-Tex standards for the textile industry, and the SONY SS-00259, Green Canon, Green ASUS S-AT2-001, and International Electronic technical Commission Quality QC080000 Restricted Substance Management standards for the electronics industry.

The performance-based EMSs were the Green Mark, Energy Label, and Carbon Footprint standards.

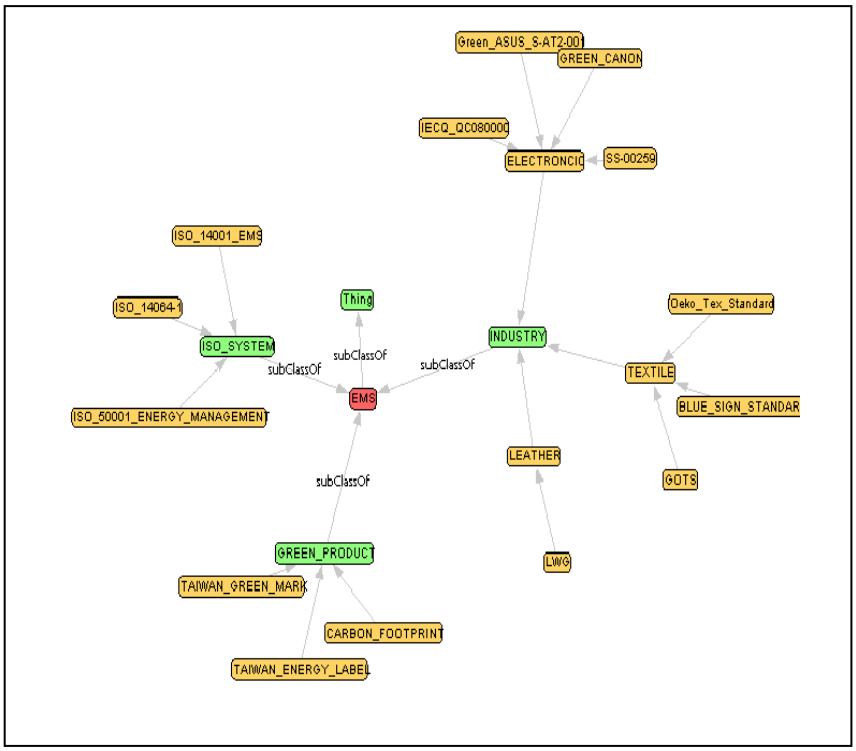

Figure 5. Ontological structure of the EMSs

4.2 Ontology-Based Leather-Industry-Exclusive Environmental Certification System

4.2.1 The EMSs of the World-renowned Sports Brands

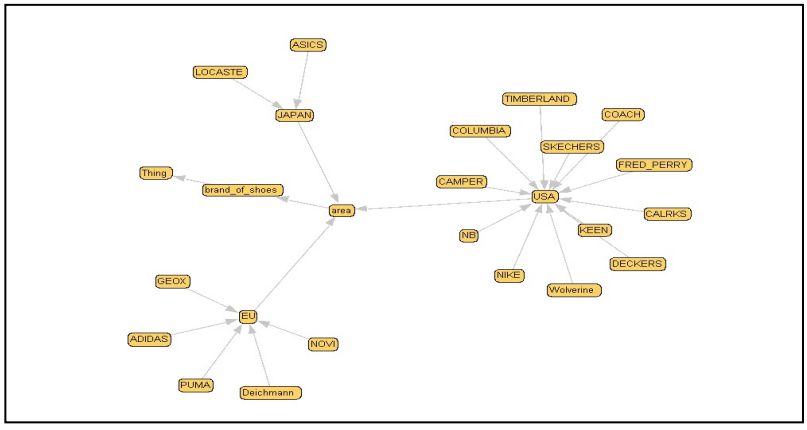

Figure 6. Ontological structure of the leather-industry-exclusive environmental certification system

The geographical regions (i.e., EU, Japan, and the U.S.A.) were designated as ontological instances for the EMSs of their respective major sports brands. The EMSs of the world-renowned sports brands in the U.S.A., EU, and Japan were collected. Figure 6 illustrates the ontological structure of the leather-industry-exclusive certification system.

4.2.2 Ontological Structure of the Environmental Certification of the Target Brands in the Leather Industry

Regarding the vertical integration model of orders extended from the ontological structure of the leather-industry-exclusive environmental certification system, the longstanding practice of original equipment manufacturers (OEMs) and leather manufacturers has been to sell leather to manufacturers of leather shoes. The OEM profit and number of orders for each leather manufacturer have commonly been constrained the shoe manufacturers who buy the leather. Shoe manufacturers may disperse their orders or request their suppliers to reduce prices, which lowers the production profits of leather manufacturers. To change this state of affairs, leather manufacturers can bypass shoe manufacturers or intermediaries, enter the supply chains of their brands through forward vertical integration strategies, and directly deliver leather to the companies that own the brands. This disintermediation can safeguard long-term orders and stable profits.

To qualify for the material supply chains of the world-renowned brands, leather manufacturers must acquire ISO 14001 EMS and LWG environmental certificates. The LWG was collaboratively formed by the world-renowned sports brands, environmental organizations, and industrial scholars in 2005. The LWG developed a set of leather industry EMSs, which concern the management of restricted substances, energy, water, wastes, leather manufacturing processes, and air quality. The LWG audit results are divided into gold, silver, and bronze ratings and provide a reference by which companies can select their suppliers.

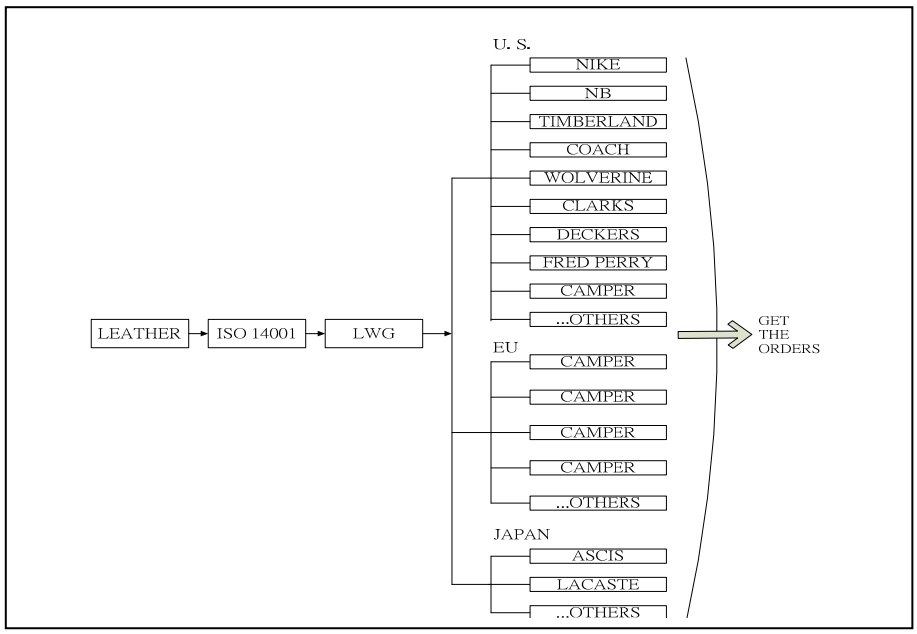

Figure 7. Ontological structure of the environmental certification of the target brands in the leather industry

Leather manufacturers must not only acquire ISO 14001 EMS and LWG environmental certificates to qualify as suppliers for brands, but also satisfy the specific requirements of potential partners to deliver their leather materials. Figure 7 lists the standards of each area and brand. Appendix 1 presents a table regarding the management system standards of the world-renowned sports brands, which details the titles, versions, and publication dates and websites of the relevant EMSs.

Figure 7 illustrates the model of the vertical integration strategy.

4.3 Ontological Structure of the Performance-based EMSs

4.3.1 The EMS Benefits Anthologies

The environmental performance indices discussed in this study relate to conserving energy and water, improving the reputations of enterprises or organizations, and reducing wastes. An ontological structure describing EMSs required to achieve these indices is depicted in Figure 8.

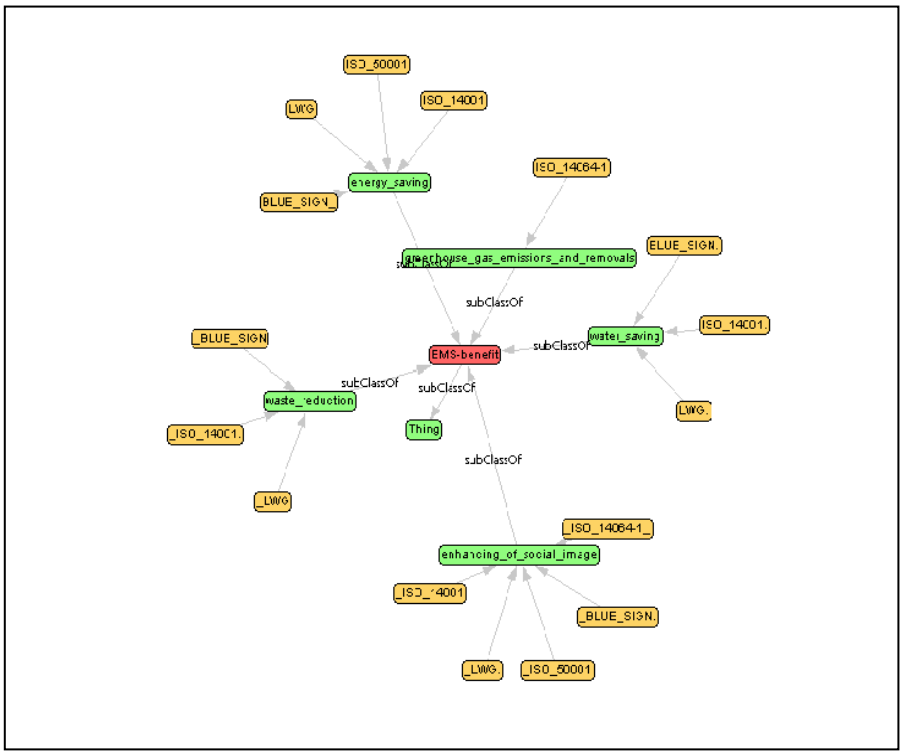

Figure 8. Ontological structure of the performance-based EMSs

4.3.2 Relationship between the EMSs and the Environmental Performance Indices

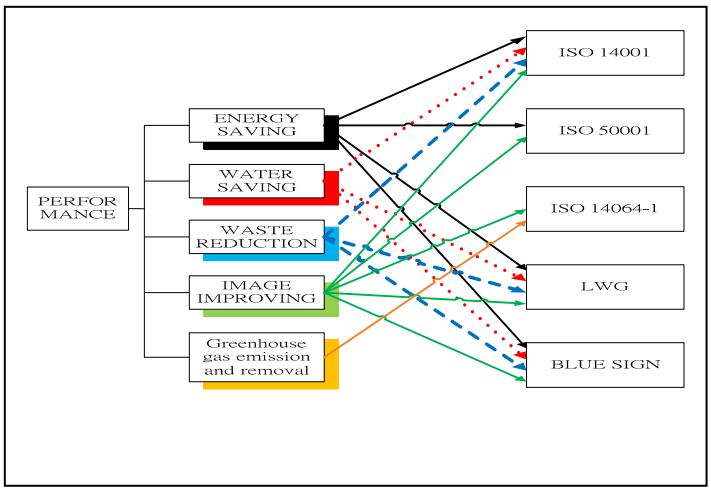

Figure 9. Relationships between the EMSs and the environmental performance indices

The ontological structure established in this study generalized the environmental performance indices achievable by each EMS, as shown in Figure 9. The common goals of all the EMSs are to enforce environmental regulations and continuously improve the environment. In addition, each EMS enables enterprises to achieve multiple goals such as saving energy and water, reducing carbon emissions, and improving corporate reputations.

The EMSs that enable enterprises to achieve various environmental performance indices are described as follows:

(1) An enterprise can improve its reputation and public image by acquiring any EMS certificate. To pass the ISO audit and acquire an EMS certificate, an enterprise must establish, implement, audit, and continually improve its EMSs and comply with all environmental regulations. Therefore, acquiring an EMS certificate earns an enterprise public approval and improves its reputation.

(2) To achieve the goal of energy conservation, an enterprise can establish and execute EMSs such as ISO

14001, ISO 50001, LWG, and Bluesign and formulate and implement energy-saving plans.

(3) To achieve the goal of water conservation, an enterprise can undertake various strategies. It can establish and execute EMSs such as ISO 14001, LWG, and Bluesign. It can formulate and implement water saving plans. It can measure and conserve the amount of water used during each work process or area through the use of monitoring systems.

(4) To achieve the goal of waste reduction, an enterprise can establish and execute EMSs such as ISO 14001, LWG, and Bluesign, formulate and implement waste reduction plans, and reduce waste production through clean production methods and waste reduction facilities.

(5) To achieve the goal of GHG reduction, an enterprise can establish and execute EMSs such as ISO 14064-1, formulate and implement GHG reduction plans, and reduce GHG production through clean production methods and GHG reduction facilities.

5. Conclusion and Recommendations

EMS certification of ISO 14001 and LWG is the basic criteria for the leather companies to establish the green competence in the international leather market. To follow the environmental regulations, customers' requirements and continually improve the environment performances are the basic and most important parts for both of international ISO 14001 and industrial LWG EMS. Furthermore, in order to meet the EMS requirements for international athlete brands, companies those who working with the brands not only have to get the ISO 14001 EMS and LWG EMS certifications but also to meet the requirements of the each brand's own standards like their RSL(Restricted Substance List), hazardous chemical managements and environment management. Therefore it is very important for leather companies working with shoe factories and/or brands to have a well-educated team, a well-organized and up to date EMS database and integrate various brands criteria to make a consistent, adequate and up to date EMS to comply with all the brands requirements. In the other hand, EMSs should be not only focus on prevention of the pollutions and compliance of the regulation, it also encourages the organizations to continually improve the environment performance. Companies passed the EMS certification can further and better practice the EMS operational managements to save the energy, water, reduce the carbon air emission and enhance the social imagine. Furthermore, to build the green competence and enhance the company competitiveness. For the market, if the leather company is able to get the ISO 14001 and LWG certificates and have the ability to build and maintain the EMS effectively to working with brand customers, there is a chance to get their own business with the brands directly instead of through the trading agent and enlarge the profit of the business.

5.1 Suggestions for Leather Manufacturers

Until now, the majority of industrial leather buyers in Asia have been shoe manufacturers, which are original equipment manufacturers for brands. For example, the Pou Chen and Feng Tay Groups in Taiwan design and manufacture sports shoes for world-renowned companies such as Nike and Adidas. The OEM profit and number of orders for each leather manufacturer have commonly been constrained by the shoe manufacturers who buy its leather products. Shoe manufacturers may disperse their orders or request their suppliers to reduce prices, thus reducing the production profit of leather manufacturers. To change this state of affairs, leather manufacturers can bypass shoe manufacturers or intermediaries, enter the supply chains of their brand through forward vertical integration strategies, and directly deliver leather to the companies that own the brands, thereby safeguarding long-term orders and stable profits.

Leather manufacturers must not only acquire ISO 14001 EMS and LWG certificates to enter the supply chains of global brands, but must also satisfy the delivery requirements of the brands. Therefore, leather manufacturers are suggested to establish environmental management teams to coordinate EMSs such as ISO 14001, LWG, and customized customer environment management requirements. Thus, leather manufacturers can integrate the ISO, LWG, and customer environment management standards, simultaneously complying with global standards, maintaining consistency with the EMSs, and reducing the costs of repeated work procedures and examinations.

Each brand has its own systems and standards. Some customers are satisfied with any supplier that can avoid using dangerous substances enumerated on simple restricted substance lists, but other customers demand that their suppliers participate in complex EMSs. Leather manufacturers must establish and manage satisfactory and regularly updated databases, integrate operations with the management standards of all brands, and establish a set of internal management standards that satisfy all customers. In addition, leather manufacturers must uniformly require their internal units and associated brands to comply with the restricted substance management standards for their products and fulfill the managerial standards of various environmental auditing requirements,

thereby fulfilling customer expectations and social responsibilities.

Leather manufacturers are required to establish quality management teams and include the EMS requirements for their products (e.g., restricted substance control and raw material control) as a part of their quality management standards. By comprehensive enforcement of quality management, leather manufacturers can avoid rejections and demands for reparations caused by the presence of environmentally hazardous restricted substances in their products.

5.2 Suggestions on Improving the Environmental Performance of the Manufacturing Industries

Establishing and implementing EMSs can enable enterprises to comply with environmental regulations and continuously improve the environment as well as conserve energy and water, reduce carbon emissions, and improve public relations. The EMSs mentioned in this study included ISO 14001 EMS, ISO 50001 Energy Management System, ISO 14064-1 GHG Emission Auditing System, LWG for the leather industry, and Bluesign for the textile industry.

ISO 14001 is a universal EMS, which fundamentally requires all enterprises to comply with environmental regulations and continuously improve the natural environment. ISO 14001 is applicable for all industries and thus all enterprises. ISO 50001 is particularly applicable for energy-intensive manufacturing industries; by establishing energy management teams, implementing energy management plans, enforcing clean production, and constructing environmentally friendly factories, energy-intensive manufacturers that adopt ISO 50001 can attain the goal of energy conservation one stage at a time.

LWG and Bluesign are exclusive EMSs that are only applicable for the leather and textile industries, respectively. These EMSs provide evaluation structures and standards to the leather and textile industries for energy, resource, water, and waste management. Furthermore, these EMSs enable leather and textile manufacturers to assess and understand their internal environmental performance. Leather and textile manufacturers are recommended to adopt these EMSs to successfully comply with environmental regulations, continuously improve the environment, and promote their reputations. In addition, through the use of these industry-exclusive EMSs, leather and textile manufacturers can more easily assess their internal environmental performance (e.g., energy, resource, water, and waste management) and improve their EMSs and environmental performance levels accordingly.

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Appendix 1. List of the management system standards for several major brands

Area	Brand	Management System Standard	Version	Links
USA	Nike	Nike, Inc., Restricted Substances List & Sustain able Chemistry Guidance	Version 1.0 January 2016	http://www.nike.com
	Columbia	Restricted Substances List(RSL) And Product Safety Manual	May 12, 2014	RSL@columbia.com.
	Clarks	Clarks Restricted Substances Manual	2015	http://www.clarks.com/CSR /home.html
	Timberland	Restricted Substance List	2015	http://www.timberland.com
	Camper	Camper - Restricted Substances List	2013	http://www.camper.com /en_TW
	Coach	QUALITY ASSURANCE Coach Restricted Substances List And Manual	v.1.4 July 2015	http://www.coach.com/international-landing.html
	Deckers	Restricted Substances Packet	August 2015	http://www.deckers.com/
	Fred Perry	Restricted Substances List	2012 V2	https://www.fredperry.com/aboutus
	NB	New Balance Lab Test Manual	Version 9.0 July 16, 2015	http://www.newbalance. com/international
	Skechers	Skechers Supplier Manual Restricted Substances Policy	2013	https://www.skechers .com/en-us
	Wolverine	Www Restricted Substance Guide	Version 1.7.1 December 2015	https://www.wewear.org/industry-resources/restricted-substances-list/
EU	Adidas	A-01	13 1 Sep., 2015	http://www.adidas-group.com/en/sustainability/managing-sustainability
	Puma	Puma Sustainability Handbook – Environmental Standards	Version 5-2016	http://about.puma.com/en/sustainability/
	Geox	Raw Materials Testing Procedure	05/09/2014	http://www.geox.biz/en/sustainability
	Deichmann	Restricted Substances List	2011-05-05	http://corpsite.deichmann.com/gb-en/our-business/sustainability-since-1913/
	Novi	Novi Restricted Substances List	March 2013	http://www.novifootwear.com
Japan	Ascis	Apparel and Footwear International RSL Management	2015	http://corp.asics.com/en/ press/article/2016-05-24
	Lacaste	Restricted Substances List	V5 March 2015	http://www.pentland.com/our-responsibility.html