CSCanada
**Management Science and Engineering**
Vol. 8, No. 1, 2014, pp. 62-67
**DOI:**10.3968/j.mse.1913035X20140801.4396

ISSN 1913-0341 [Print]
ISSN 1913-035X [Online]
www.cscanada.net
www.cscanada.org

# Chinese Wisdom on Eco-Innovation Management

XIAO Jing[a],*

[a]Economics and Management School, Changchun University of Science and Technology, Changchun, China.
*Corresponding author.

**Supported by** Foundation of philosophy and social science planning, Changchun City (No.2012SSK10)

Received 2 December 2013; accepted 18 February 2014

## Abstract

**Purpose**: The purpose of this paper is to find out theoretical ground to improve the eco-innovation performance in enterprises from traditional Chinese ecological point of view.

**Design/methodology/approach**: Implications of traditional Chinese ecological thoughts on eco-innovation performance were analyzed textually. Based on it, both business and societal benefits as output indicators were proposed to evaluate the eco-innovation performance in enterprises and the theoretical framework was established. To test it, the survey data were collected from 10 electronic and communication equipment manufacturers in P.R.C. and the DEA models were used.

**Findings:** The estimated results show that it is more efficient to evaluate eco-innovation performance by outputs including business and societal benefits than by solely economic benefits and eco-innovation performance in most selected enterprises is DEA inefficient. The sample study shows the managerial measures of improvement to a DEA inefficient eco-innovative enterprise.

**Research limitations/implications**: A large samples from high-tech industrial enterprises, as well as multi-industrial samples are more revealing to test the evaluation system than samples from Electronic and Communication Equipment manufacturers. In addition, according to the DEA theory, relative efficiency rather than absolute efficiency of eco-innovative performance is calculated, so the managerial suggestions of the sample study could be weakened.

**Practical implications**: The ecological values embedded in traditional Chinese wisdom could be applied to guide ecological development of innovation performances in Chinese enterprises. Chinese enterprises should pay same attention to societal benefits as well as business benefits in their eco-innovations, and explore the strength from traditional Chinese wisdom to be sustainable and competitive.

**Originality/value**: It explains a Chinese characteristic way of evaluating eco-innovation performance by exploring implications from the traditional Chinese ecological ideas.

**Key words:** Chinese wisdom; Ecological value; Eco-innovation; Business benefits; Societal benefits

XIAO Jing (2014). Chinese Wisdom on Eco-Innovation Management. *Management Science and Engineering*, *8*(1), 62-67. Available from: http://www.cscanada.net/index.php/mse/article/view/j.mse.1913035X20140801.4396
DOI: http://dx.doi.org/10.3968/j.mse.1913035X20140801.4396

## INTRODUCTION

Joseph A. Schumpeter proposed innovation theory in his book named “the Theory of Economic Development”. From economic point of view, he pointed out that innovation is establishing a production function, which introduces a combination of new factors or new conditions to production system, in order to gain excess profits (Wang, 2010). Enterprises are major conductors from the innovative point of view. They are responsible for transforming natural resource and usable resource produced by other organizations to consumable products. Therefore, they have the greatest effects on resource and environment. In the pursuit of economic benefits, many enterprises have no sense of natural resources shortage and of social responsibility to protect the environment so as to take quick profit methods, which exacerbate ecological damage.

These problems stem from lacking ecological values. Therefore, enterprises should integrate ecological concerns into their innovation performance, that is, do eco-innovation. Eco-innovation is a relative new concept and is defined as new products and processes which provides customer and business value but significantly decrease environmental impacts (Peter, 1997). According to the European Commission's Environmental Technologies Action Plan (ETAP), eco-innovation encompasses technologies and processes to manage pollution, less polluting and less resource-intensive products and services, as well as ways to manage resources more efficiently. It seems to be difficult, but it has been done consciously or unconsciously by enterprises around world. LED is a typical case. It has been innovated for being lighter and more durable. Its additional feature of energy-efficiency made it a famous eco-innovation. In addition, it is reported that more than 60 % of innovations offer environmental benefits in the Netherlands.

Although it is not similar statistics in China, it reminds us to set up evaluation measurements to help Chinese enterprises understanding their eco-innovation performance better in the competitive market. Many studies use a single indicator argued that the specific indicator that is applied has fewer shortcomings than multiple indicators (Hagedoorn & Cloodt, 2003). It is maybe because that it is difficult to calculate the weightings of multiple indicators of innovative performance (Wu, 2009). Therefore, it is hardly to understand measurement of eco-innovation performance.

There is a profound theoretical foundation of the ecological thoughts in China. The ancient Chinese put forward their ecological thoughts, which were inherited and carried forward as an important part of Chinese culture. This inspires us to dig wisdom from these ecological ideas that are rich in Confucian, Taoist and Mohist thoughts in order to establish a Chinese characteristic evaluation system and to guide Chinese enterprises to perform eco-innovations efficiently.

In the rest of paper, in the textual analysis section, evaluated items are proposed based on the implications of traditional Chinese ecological thoughts on eco-innovation enterprises. In the frameworks and methods section, then the theoretical framework is formed and the research methods are selected. In the empirical analysis section, the findings are explained. In the results section, managerial suggestions are explored.

## 1. TEXTUAL ANALYSIS OF CHINESE WISDOM AND ECO-INNOVATION

According to the implications of traditional Chinese ecological thoughts on eco-innovation and its management, this paper proposes a series of items that should be evaluated.

### 1.1 Ecological Value "Tianren Heyi" and Eco-Innovation

As a typical summary of traditional Chinese ecological ideology, Tianren Heyi means harmony between man and nature. On the one hand, Taoist scholars explained it as "Daofa Ziran", that is, imitation of nature. They argued that people should respect life and let nature take its course. The soul of this thought is "naturalism". On the other hand, Confucian scholars summed it up as "Renzhe Airen", which means that the benevolent loves others. In other word, people have obligation to nature as well as other people. "The Doctrine of the Mean" mentioned the "Yu Tiandi Can" or participation of man in nature, that is, people are responsible for achieving harmony between themselves and planet by following the laws of nature. Although there is different explanation about people' role in nature, there is no dilemma about ecological morality in human's activities.

Referring to this thought, people should keep ecological value in mind while playing their role in the world. It leads enterprises to construct harmonious relationship with nature in their business. Therefore, enterprises should innovate ecologically if they contribute to overall welfare in the sense of well beings besides economic growth, for present benefits do not mean anything to the sustainability.

### 1.2 Concept "Qiangben Jieyong" and Business Concept of Eco-Innovation

Mozi proposed the concept of "Qiangben Jieyong". "Qiangben" refers to enhance the agriculture production, and "Jieyong" refers to economize resources. In other word, in the production activities, resource consumption efficiency is as important as economic benefit.

As to how to consume resource efficiently, in the Analects of Confucius, Confucius advocated that the guidelines for planting period should be followed when people carry out agricultural production. In the words of Mencius, Mencius put forward a series of ideas about how to take rational use of natural resources. For example, even if it is in the season of harvest, in order to achieve sustainable development, people should control harvest and overfishing. Namely, it is recommended that people should be vigilant in peace time, get resources in the right way, and use them in the proper degree.

It reminds us that enterprises should attach the same importance to economic and resource benefits from eco-innovation activities. For the eco-innovators, economic benefits and resource benefits are related to business directly, which consist of sales from commodities, or cost saving from better logistics and greater resource productivity.

Therefore, referring to traditional Chinese ecological ideas, economic benefits and resource benefits are included in the evaluation system of eco-innovation performance in enterprises.

### 1.3 Concept "Shangzhi Fuguo" and Societal Benefits of Eco-Innovation

In the Xunzi·Wealth of Nation, Xunzi comes up with the idea "Shangzhi Fuguo", in which "Shangzhi" goes ahead and "Fuguo" follows. "Shangzhi" refers to good governance and "Fuguo" refers to social reputation and a rich country. In other word, people should instill new ideas to deal effectively with the state of nature, and then a prestigious and rich community will be established. As to how to govern well, the Xunzi Kingship mentioned that, according to the laws of nature, people should develop their creativity, use scientific and technological knowledge to combine exploitation, protection and governance of nature, so as to save environmental costs and increase social benefits.

Referring to that, enterprises should make judgments on their eco-innovation performance by the environmental benefits and social benefits, which are often ignored. Figures on environmental and social benefits on eco-innovation or even innovation are not collected by enterprises by themselves (by the government in China), it leads many enterprises to believe that environmental and social benefits conflict with their economic benefits. It can be explained by the fact that, for eco-innovative enterprises, compared with economic and resource benefits, the environmental and social benefits will contribute their development indirectly. It is common that environmental cost is internalized, but the ecological attributes of products, services and process are mostly intangibles. Even if it takes time, the way enterprises protect environment and manage their business ecologically will be acknowledged and valued in the market. That is how enterprises build up their reputation and gain sustainable capacity. The immense potential of profiting from eco-innovation comes from better image, from customers' approval of an enterprise through their shopping behavior, from greater worker satisfaction and so on. For example, Wuliangye Group adopted the ecological business mode, developed a harmless technical processing to discharge lees and developed a technology to produce lactic acid from waste water. As one of Chinese well-known wine trademarks, its brand value was evaluated at CNY 68.592 billion in 2012 and its reputation has been testified again nationally and internationally.

According to the implication from the traditional Chinese thoughts, the environmental and social benefits are taken as parts of indicators of evaluation on eco-innovation performance in this study.

## 2. RESEARCH FRAMEWORK AND METHODS

Referring to implication from the traditional Chinese wisdom, Chinese enterprises should build up eco-oriented goals of innovation activities, determine and adjust eco-innovation inputs based on the analysis of both business and societal benefits, and transform these eco-innovations into the source of sustainable capacities and competitive advantages. Therefore, this study proposes a conceptual framework to access eco-innovation performance in enterprises as shown in Figure 1.

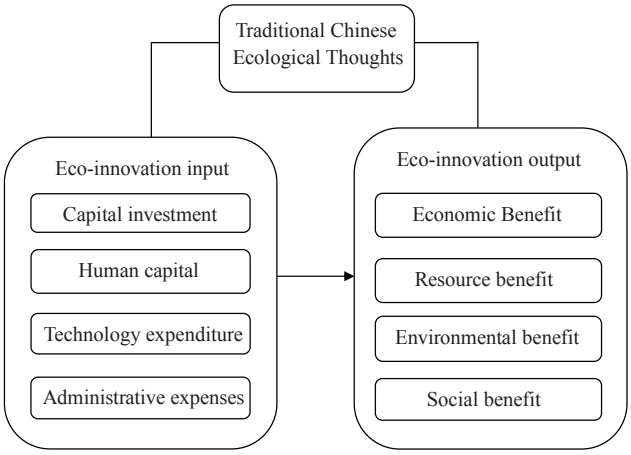


**Figure 1**
**Conceptual Framework**

To test the conceptual framework above, this study chose indices and set up the eco-innovation input and output evaluation system as follows.

**Table 1**
**Evaluation System of Eco-Innovation Input and Output**

| | Targets | Definition |
|---|---|---|
| Input | Capital investment (X1) | Capital investment means the ratio of eco-innovation expenditures to the sales revenue of enterprise. |
| | Human capital (X2) | Human capital means the ratio of the number of employees involved in eco-innovation to the total. |
| | Technology expenditure (X3) | Technology expenditure is defined as the ratio of the total expenditures on acquisition, transformation and absorption of technologies to the sales revenue of enterprise. |
| | Administrative expenses (X4) | Administrative expenses are indicated by the share of expenses on transforming achievements into productivity with the sales revenue of enterprise. |
| Output | Economic benefits (Y1) | The share of after tax profit margin of products with the sales revenue stands for economic benefits. |
| | Resource benefits (Y2) | Reduced proportion of comprehensive energy consumption per unit of output stands for resource benefits. |
| | Environmental benefits (Y3) | The level of pollution reduction stands for environmental benefits |
| | Social benefits (Y4) | Increased percentage of enterprise' brand value stands for eco-social benefits. |

To test the efficiency of evaluating eco-innovation performance from the perspective of integrated outputs, the Data Envelopment Analysis (DEA) was applied. The DEA is usually used to evaluate the productive efficiency of decision making units (DMUs) that use multiple inputs to produce multiple outputs. It has the benefit of not giving an input-output functional form and weights. It can measure the relative efficiency of DMUs synthetically and objectively based on observed inputs and outputs. Therefore, DEA is the best way to test the relative efficiency of eco-innovation in Chinese enterprises.

To measure the technical efficiency of DMU and the scale efficiency of the inputs at the same times, C2R model C2R model with non-Archimedean infinitesimal vector ε is established as follows:

$$(D_g)\begin{cases}\min[\theta-\varepsilon(\hat{e}^T s^- + e^T s^+)]\\ s.t.\Sigma_{i=0}^{n}\lambda_j x_j + s^- = \theta x_0\\ \Sigma_{i=0}^{n}\lambda_j x_j - x^+ = y_0\\ s^- \geq 0, s^+ \geq 0, \lambda_j \geq 0, j = 1,2,\cdots n\end{cases} \quad (1)$$

Suppose the optimal solution to the programming issue ($D_g$) are $\lambda^*, s^{*-}, s^{*+}, \theta^*$, if $\theta^*<1$, the DMU $j_o$ is DEA inefficient; if $\theta^*=1$, together with $s^{*-}=0, s^{*+}=0$, the DMU $j_o$ is DEA efficient.

If returns to scale are variable, $C^2GS^2$ model is established to measure the pure technical efficiency as follows:

$$(p_g)\begin{cases}\max(\mu^T y_0 + \mu_0) = V_p(\varepsilon)\\ s.t. w^T x_j - \mu^T y_j - \mu_0 \geq 0, j = 1,2,\cdots,n\\ w^T x_0 = 1\\ w^T \geq \varepsilon\hat{e}^T, \mu^T \geq \varepsilon e^T\end{cases} \quad (2)$$

Suppose the optimal solutions to the linear programming issue ($P_g$) are $w^0, \mu^0, \mu^0_0, V^*_p$, if $w^0>0$, $\mu^0>0$, together with $V^*_P<1$, the DMU $j_0$ is DEA efficient; if $V^*_P<1$, the DMU $j_0$ is not DEA efficient.

Let $\hat{x}_0 \triangleq \theta x_0 - s^{--} = \Sigma_{j=0}^{n}\lambda_j x_j$ and $y_0 \triangleq y_0 + s^{--} = \Sigma_{j=0}^{n}\lambda_j x y_j$, then $(\hat{x}_0, \hat{y}_0)$ is the projection of $(x_0, y_0)$ onto the efficient frontiers. $(\hat{x}_0, \hat{y}_0)$ is DEA efficient compared with initial $(x_0, y_0)$.

For evaluating purpose, 10 Electronic and Communication Equipment manufacturers that involve in eco-innovations in China were selected as DMUs. The original data were collected from their Annual Financial Reports in 2010 and the census. The data was analyzed by using Lingo software. See the results in Table 2.

**Table 2**
**Efficiency of scale and technology of DMUs**

| | Score | | | Relative efficiency | Scale efficiency | Technological efficiency | Input-output performance |
|---|---|---|---|---|---|---|---|
| | $\theta$ | $\theta'$ | $V_P$ | | | | |
| 1 | 0.9952 | 0.9952 | 1 | DEA inefficient | Decreasing | Efficient | Adjusted |
| 2 | 0.8161 | 0.5222 | 0.9854 | DEA inefficient | Increasing | Inefficient | Adjusted |
| 3 | 1 | 1 | 1 | DEA efficient | Proper | Efficient | Relative best |
| 4 | 0.8437 | 0.5399 | 0.8439 | DEA inefficient | Decreasing | Inefficient | Adjusted |
| 5 | 0.9113 | 0.7582 | 1 | DEA inefficient | Increasing | Efficient | Adjusted |
| 6 | 1 | 1 | 1 | DEA efficient | proper | Efficient | Relative best |
| 7 | 0.9994 | 0.8589 | 1 | DEA inefficient | Decreasing | Efficient | Adjusted |
| 8 | 0.9607 | 0.7031 | 1 | DEA inefficient | Increasing | Efficient | Adjusted |
| 9 | 0.7548 | 0.7548 | 0.9994 | DEA inefficient | Decreasing | Inefficient | Adjusted |
| 10 | 1 | 1 | 1 | DEA efficient | proper | Efficient | Relative best |

In the Table 2, the estimates are consistent with the theoretical expectation. The coefficient $\theta$ was calculated on economic benefits only. The coefficient $\theta'$ was calculated on comprehensive outputs listed above. According to the data, first, the coefficient $\theta'$ is obviously lower than $\theta$ in the majority of these enterprises; second, the average of the coefficient $\theta'$ 0.8132 is lower than that of $\theta$ 0.9281. Thus it can be concluded that, it is more efficient to evaluate eco-innovation performance in terms of economic efficiency, resource consumption efficiency, environmental benefits and social benefits than from solely economic point of view in these enterprises. In this paper, it reminds us even of going a further step to argue that, Chinese enterprises could dig wisdom from traditional Chinese ecological thoughts to get strength in their eco-innovation performance.

Furthermore, among all DMUs, the enterprises 3, 6 and 10 are both scale and technical efficient, that is, the eco-innovation performance is relatively best in these enterprises. The results can be explained by the ecologically sensitive value in these enterprises. For example, enterprise 6 is famous for its ecologically friendly production. Specifically, she set up an eco-sensitive culture and involved herself actively in eco-innovation funding programs open to all forms of innovation looking to reduce environmental footprint and optimize the use of resources. The enterprises 1, 5, 7 and 8 are inefficient in scale but technical efficient, that is, inefficiency of scale is caused by the other factors rather than eco-innovation input. The enterprise 2, 4 and 9 are all inefficient, that is, the inefficiency of resource

allocation restricts the efficiency of the eco-innovation performance in these enterprises. The enterprise 2 has increasing returns of scale, that is to say, it should expand the eco-innovation inputs to promote eco-innovation output. In contrast, the enterprise 4 and 9 have decreasing returns of scale, that is to say, they should improve the management rather than expand the scale to enhance eco-innovation outputs.

In order to enhance the eco-innovation performance, inputs and outputs of the typically inefficient enterprise 4 were analyzed. See results in Table 3.

**Table 3**
**Input and Output of Inefficient DMU 4**

| | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $Y_1$ | $Y_2$ | $Y_3$ | $Y_4$ |
|---|---|---|---|---|---|---|---|---|
| Original value | 0.0061 | 0.062 | 0.76 | 0.27 | 0.085 | 0.085 | 0.098 | 0.084 |
| Optimal value | 0.0051 | 0.029 | 0.64 | 0.06 | 0.087 | 0.126 | 0.110 | 0.113 |
| Gap (%) | 16.39 | 53.75 | 15.61 | 77.83 | 2.35 | 48.02 | 11.94 | 34.5 |

In table 3, first, the gap ratio of capital investment (X1) and technology expenditures (X3) are relatively low. For capital investment, referring to the original value, it can be explained by the general lower level of capital investment rate in this group of DMUs. Therefore, R&D expenditures on eco-innovations should be enhanced to achieve sustainability and competitiveness. Second, referring to administrative expenditures (X4), although the original data is the highest among the 10 enterprises, it shows a huge gap between the original value and the optimal value. It means that the inefficient use of operating spending is the vital weakness of this enterprise. Third, according to the estimation of human resource, the volume of workforce input in eco-innovation activities can be saved by 53.75%, that is to say, the staff involved in eco-innovations are either incapable or ineffective or both. Some professional training and education system or employee incentive mechanism will help them do better job.

## 3. MANAGERIAL IMPLICATIONS

Based on the implication of Chinese wisdom and results of sample analysis in this study, the management recommendations are proposed.

First, create a good ecological context. The experience of the DEA efficient DMUs shows the important of context conductive to eco-innovation. For enterprises, the context can be external and internal. External environment mainly relates to policies, technological, social, economic and ecological factors. For example, as a social factor, enterprises should take effective use of intermediary service organizations in order to get help from information consultancy, and technological training and innovation cooperation about enterprises' ecological development. On the other hand, internal environment mainly refers to the business goals, scientific and technological strengths, management methods, and organizational structure and so on. Enterprises should keep eyes on the trends of societal factors in the innovation process; create ecological business model and strength eco-oriented management.

Second, set up ecological sensitive corporate culture. Eco-innovations involve in the parallel process of generation of innovative ideas, R & D, design and manufacturing and marketing. Every aspect of eco-innovation is closely related to corporate culture. According to Dennis K. Mumby's (1996) study, corporate culture has three layers: consciousness in the deep level, values in the intermediate level and organizational structure and behavior on the surface. Therefore, at different levels, the construction of ecological sensitive culture of innovative enterprises includes as follows:

• It is fundamental to ingrain ecological consciousness in the deep structure of the corporate culture. Ecological consciousness is the basis of corporate culture and behavior norms, which are able to trigger eco-innovations and lead to enterprise ecology.

• It is important to set up eco-oriented value in innovation performance and management according to market demand and trend of science and technology.

• It is necessary to allocate rationally all kinds of resources, and to adjust organizational structure and organizational behavior with the eco-sensitive goals in operations.

Third, cultivate capable participants in eco-innovative enterprises. Participants' enthusiasm and their potential is a significant determinant of innovation achievements. Eco-innovative activities, as a complicated and systematic engineering, involve in a wide range of closely collaborated people, mainly including managers, employees, as well as other participants or the greater community. As to managers, enterprises should set up eco-manager system. In this system, the appointed managers should have sound ecological entrepreneurial spirit, as well as enough rights to solve conflicts between ecological development and other performances in enterprises. As to employees, enterprises should offer education and training programs to mold or enhance their ecological values and capacity so as to eco-innovation performance. As to others, take customers for example, enterprises should also cultivate their loyal customers by steering them to choose environmentally sound products, which in turn will stimulate the ecological development of the enterprises in a greater community.

Fourth, establish dual-level eco-innovation system. Eco-innovation system can be divided into two dynamic levels, that is, technological level and managerial level. At the technological level, enterprises focus on product eco-innovation and process eco-innovation that can be carried out for pollution-free production, energy saving and so on. At the management level, enterprises should set up the management mode suitable for ecological innovation.

In this system, innovation is the means and management is the basis for ecological development. The two are interdependent and support each other in order to achieve ecological goals.

## CONCLUSION

Although eco-innovation is a relative new concept and is more popular in the western countries than in China, it gets implications from Chinese wisdom. Among the traditional Chinese ecological ideas, the concept "Tianren Heyi" implies that enterprises should innovate ecologically if they contribute to overall welfare in the sense of well beings besides economic growth. The concept "Qiangben Jieyong" tells enterprises to evaluate eco-innovative performance according to their business benefits, achieving from direct economic returns and resource consumption efficiency. The concept "Shanzhi Fuguo" caveats enterprises evaluate and adjust their eco-innovation performance according to societal benefits, gaining from environmental protection and social reputation. The positive results from the sample study remind Chinese enterprise to build up their strength from Chinese ancient wisdom in the process of eco-innovation activities and eco-innovation management.

## REFERENCES

Allenby, B. (1994). Integrating environment and technology: Design for environment. In B. R. Allenby, & D. J. Richards (Eds.), *The greening of industrial ecosystems* (pp.137-148). Washington D. C.: National Academy Press.

Anthony, S., Chiu, F., & Geng, Y. (2004). On the industrial ecology potential in Asian Developing Countries. *Journal of Cleaner Production, 12*( 8/10), 1037-1045.

Boulding, & Kenneth, E. (1968). *The organizational revolution: A study in the ethics of economic organization.* Chicago: Quadrangle Books.

Chris, F. (1982). *The economics of industrial innovation* (2nd ed.). London: Printer.

Dennis, K. M., & Cynthia, S. (1996). Disciplining organizational communication studies. *Management Communication Quarterly, 10*(1), 50-72.

Hagedoorn, J., & Cloodt, M. (2003). Measuring innovative performance: Is there an advantage in using multiple indicators?. *Research Policy, 32*, 1365-1379.

Isenmann R. (2002). Further efforts to clarify industrial ecology's hidden philosophy of nature. *Journal of Industrial Ecology, 6*(3/4), 27-48.

James, P. (1997). The sustainability circle: A new tool for product development and design. *Journal of Sustainable Product Design, 2*, 52-57.

Jean, G. S., & Edward, S. (2000). Eco-enterprise strategy: Standing for sustainability. *Journal of Business Ethics, 24*(4), 313-329.

Jia, J. F. (1998). *Science of technological innovation* (1st ed.). Beijing: Tsinghua University Press.

Jian, Z. X., & Li, J. W. (2010). Correlation analysis of technology innovation ability and ecological level. *Soft Science, 24*(10). 10-15.

Jo, D., & Herman, V. L. (2008). Exergy: Its potential and limitations in environmental science and technology. *Environmental Science and Technology, 42*(7), 2221-2232.

Jouni, K. (2004). Industrial ecology in the strategic sustainable development model: Strategies applications of industrial ecology. *Journal of Cleaner Production, 12*(8/10), 809-823

Kristan, C. (2004). Innovative industrial ecology education can guide us to sustainable paths. *Technological Choices for Sustainability*, 77-90.

Mansfield E. (1968). *Industrial research and technological innovation : An econometric analysis*. New York: Norton.

Moore, J. F. (1996). *The death of competition: Leadership and strategy in the age of business ecosystems*. New York: Harper Business.

Robert, U. A. (2004). On the life cycle metaphor: Where ecology and economics diverge. *Ecological Economics, 48*(4), 425-438.

Shrivastava, P. (1995). The role of corporations in achieving ecological sustainability. *Academy of Management Review, 20*, 936-960.

Starik, M. & Rands, G. (1995). Weaving an integrated web: Multilevel and multisystem perspectives of ecologically sustainable organizations. *Academy of Management Review, 20,* 908-935.

Tian, S. (2002). Ecological economics in China: Origins, dilemmas and prospects. *Ecological Economics, 41*(1), 5-20.

Urmila, D. (2005). Green process design, industrial ecology, and sustainability: A systems analysis perspective. *Resources, Conservation and Recycling, 44*(3), 215-235.

Welford, R., & Gouldson, A. (1993). *Environmental management and business strategy.* London: Pittman.

Wu, L. (2009). The evaluation of enterprise eco-technological innovation performance based on DEA method. *Science & Technology Progress and Policy, 26*(18), 114-117.