Int. J. Environ. Res., 4(4):751-758 , Autumn 2010
ISSN: 1735-6865

Improving Competitive Advantage with Environmental Infrastructure Sharing: A Case Study of China-Singapore Suzhou Industrial Park

Yuan, Z., Zhang, L., Zhang, B., Huang, L., Bi, J.* and Liu, B.

State Key Laboratory of Pollution Control and Resource Reuse, School of the Environment, Nanjing University, Nanjing 210093, P. R. China

Received 7 Sep. 2009; Revised 9 May 2010; Accepted 19 May 2010

ABSTRACT: As one way to approach industrial symbiosis, environmental infrastructure sharing is principally concerned with providing an integrated environmental utility system for clustered firms. It is based on the assumption that environmental infrastructure sharing can improve the regional competitive advantage by reducing overall cost and improving environmental performance. In order to verify the assumption, the research examines the cost-effectiveness of wastewater treatment system of China-Singapore Suzhou Industrial Park between the isolated model and sharing one. The results show that the sharing mode can greatly reduce the overall cost and furthermore provide competitive advantage comparing to the isolated one. In addition, it also improves the overall environmental performance and enforces the cooperation among clustered companies, which creates a good integrated image and attracts more and more excellent enterprises to join in.

Key words: industrial symbiosis, eco-industrial parks; cost-effectiveness, environmental management

INTRODUCTION

Recently, environmental management studies have been taken into the consideration in lots of Asian countries (Abbaspour et al., 2009; Khadka and Khanal, 2008; Mohammadrezaie and Eskafi, 2007; Shobeiri et al., 2007; Chien and Shih, 2007). As one of the three principal enterprise strategies, the overall cost leadership plays an important role in the improvement of enterprise's competitive advantage (Michael, 1980). Geographic proximity of different firms especially small and medium-sized enterprises in a certain area, called industrial clusters (Heiner, 2005), will greatly reduce the costs of transaction, transportation, and cooperation with the conveniences of materials sourcing, service providing, pools of skilled labor hiring, and other similar advantages (Sturgeon, 2003; Masahisa and Paul, 2004). However, the clustering of many different kinds of firms in a limited area inevitably brings intensive pollutant emissions. It will be more serious provided inefficient environmental infrastructure system (Boland et al., 1997) and rather low resource productivity and eco-efficiency (Allenby, 2004). Conventionally, environmental engineering technologies were used to decrease the pollutants with the help of environmental infrastructure system. However, these end-of-pipe approaches always transport pollutants from one place to another or transform them from one kind to another. They do not really clean or demolish the pollutants, and so are very easy to cause the pollution in a new form or place again. Furthermore, these approaches heavily rely on plentiful chemical materials inputs and huge energy consumption, and so they are usually too costly to function continuously.

In order to improve resource productivity and prevent pollutant discharges in a cheaper way, the concept of utilizing one firm's effluents as inputs of another came into being (Graedel and Allenby, 2004; Frosch and Gallopoulos, 1989). It is called industrial symbiosis (IS) which principally concerned with the cyclical flow of resources through networks of business as a means of cooperatively approaching ecologically sustainable industrial activity (Chertow et al., 2005). IS has a more meaningful definition comparing to industrial cluster because it includes not only the geographical proximity but also the cooperative management of resources and environment among the co-located firms.

Based on empirical models, IS has three kinds of linkages (symbiotic relationships) among different firms: a) products or service-related; b) by-products exchanges; c) (environmental) infrastructure and service sharing (YUAN and Bi, 2007). The a) adds environmental and resource utilization management into the concept of conventional supply chain (Adam

*Corresponding author E-mail: jbi@nju.edu.cn

et al., 2002). It is usually called green/environmental supply chain management in the field of economic management and related research is focused on material flow analysis (Paul and Helmut, 2004; Jonathan et al., 2007), system metabolism analysis (Lave, 1995), and integrated performance management (Lisa, 2005; Peter, 2002;). The b) is an important characteristic for eco-industrial parks and also a prevalent sub-field of IS. Its core is to explore ways of constructing a waste closed-loop or developing waste exchange relationships among co-located firms step by step (Cote and Cohen-Rosenthal, 1998). The evaluation of economic profit and environmental benefit from by-products exchanges is also an important part of the field. The c) is a platform for the communication and material (wastes) exchange among co-located firms. Furthermore, the c) also affects the links between local commons and regional and global systems (Wolfe and Meric, 2004). However, little attention has been paid on the environmental infrastructure sharing (Gale, 2005; Thomas et al., 2003) except a few literatures on the investment model and operation mechanism (Marcus, 2005; Zeng, 2006;), and the cost-benefit analysis (Chertow et al., 2005).

According to Porter's results (Michael, 1980), environmental infrastructure sharing would improve the competitive advantage of industrial symbiosis. In fact, it is consciously or unconsciously assumed by almost all the IS research. But is the environmental infrastructure sharing really able to reduce the overall cost? In order to verify the assumption, the research aims at examining the cost-effectiveness of environmental infrastructure sharing by comparing it with a virtual isolated/individual environmental infrastructure model. The research chooses China-Singapore Suzhou Industrial Park (CSSIP) as the case of study because it owns the first-class environmental infrastructure sharing system and is one of the most developed industrial parks in China. Furthermore, considering the accessibility of data and the similarity of different environmental infrastructure utilities, the research focuses only on the cost-effectiveness analysis of wastewater treatment plant (WTP). The following part of the paper introduces the environmental infrastructure sharing system of CSSIP, and the third part talks about the methodology, followed by the cost-effectiveness analytical model. The last two parts of the paper provides the results and conclusions respectively. As the largest economic and technological cooperation program between Chinese and Singaporean Government, CSSIP aims to develop into "a high tech industrial park of international competitiveness, a garden-like, ecological, international and digital new town". CSSIP is located in the east of Suzhou, China and was born on February 26, 1994. It covers an area of 288km^2 in which there is a zone of 72 km^2 to be developed collaboratively (core-area). Before 2001, almost all the managers of CSSIP committee come from Singapore and they play the most important role in the development of CSSIP. Throughout the duration, CSSIP formed a high efficient management system of "small government, large society", and provides companies with the best and possible convenient service. As for the end of June 2008, CSSIP had attracted 77 Fortune 500 MNCs investing here. Its local gross domestic product (GDP) added up to 1001.5 billion RBM in 2008. The primary industry of CSSIP is electronic manufacturing. 71% investment comes from foreign companies, with 15.1% of the companies coming from America, 13.1% from Europe, 10.8% from Japan and Korea, 16.2% from East Asia countries and Areas, and 43.2% from Hong Kong, Macau, and Taiwan regions. Obviously, the quick development of CSSIP depends on its unique political and preferential policy advantages. According to the development plan of the park finished in 1994, CSSIP would complete a worldwide first-rate infrastructure sharing system (called "Jiu tong yi ping" in Chinese) before the companies' coming. The system includes street paving, supply of electricity, fresh water, gas, heat, sewerage, post and telecommunication, digital TV service, and land-filling. All the companies investing in the park must share the infrastructures and it benefits a lot to the success of CSSIP. Up to now, CSSIP is the only industrial park that provides the infrastructure sharing system in China (Fig. 1).

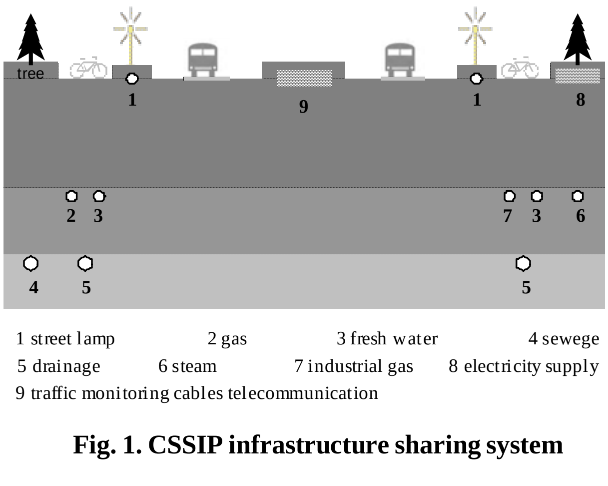
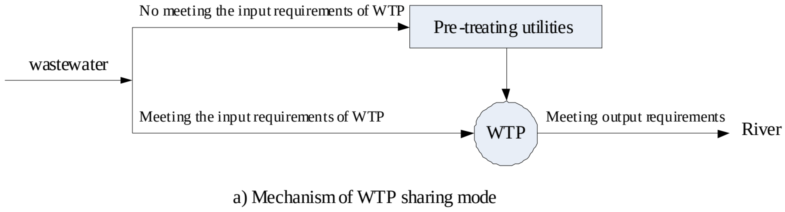


Fig. 1. CSSIP infrastructure sharing system

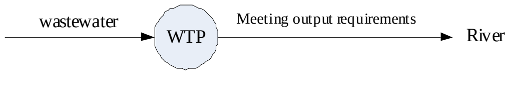
MATERIALS & METHODS

In the study, most basic data related to the economic, social, and environmental situation of Suzhou and CSSIP comes from the webpage (http://www.sipac.gov.cn/english). Other data such as environmental standards, laws, and annual reports comes from the Ministry of Environmental Protection website (http://english.mep.gov.cn). Furthermore, the CSSIP[1] governors were interviewed with the help of environmental officials. The study collected the following data from the environmental protection bureau of CSSIP commission: 1) Historical database such as Forms of Pollutants Application and Registering; 2) environmental assessments of construction projects; and 3) other annual statistical data. Based on the above information, a field survey was carried out in May 2007 so as to get detailed information about the firms in the park. Six investigators were involved in the survey after a professional training. They were divided into three groups and every group consisted of two investigators. Every group completed two tasks in surveyed companies: interviewing environmental managers/operators and observing/visiting the production lines shown around by the environmental managers or technicians of the company. The whole process of the survey lasted two weeks and more than sixty company managers/operators were interviewed. The selection of surveyed companies was based on a comprehensive consideration of industrial sectors, investment scale, ownerships, and products. The main contents of the interview covered but were not limited to: 1) introduction of the company including its annual sales, employee, capital, and investors; 2) the supply chain system; 3) feedstock and effluent[2]; 4) the main environmental problem and environmental protection activities. Finally, in order to verify the validity of collected official statistics, a questionnaire is designed and distributed to the selected 493 companies in the park. All the questionnaires are mailed to the environmental managers of companies located in the core area. In the mail, there is an official announcement, one questionnaire, and a stamped empty envelope. The announcement is prepared by CSSIP committee explaining the object, requirements, and importance of the survey. The stamped empty envelop is for the questionnaire mailing back. All these questionnaires are required to be sent back to the environmental protection agency of CSSIP in two weeks. In the other areas, the questionnaires are distributed by the environmental protection assistants of the four towns according to the distribution principles as follow: First, all the companies are classified into four kinds according to their main products, and then in every classification, companies are further classified into two kinds: foreign and domestic. Finally, all companies are listed one by one according to the amount of their gross sales of year 2006. The surveyed companies are selected averagely. Provided that the gross investment and gross sales of foreign companies are far more than that of domestic companies, the ratio of surveyed foreign companies is higher than that of domestic companies. At the same time, more than 70% companies are located in the core area, so the ratio of surveyed of core area is higher than that of around areas.

In the present mode, all companies located in CSSIP will have to share the WTP system. But before they discharge wastewater into the WTP, they will have to ensure that their wastewater quality can meet the requirements of the WTP, or they will have to build their own pre-treatment utilities. The mode mechanism is shown in the a) of Fig. 2. In order to examine the cost-effectiveness of WTPs, the research provides a virtual mode of individual WTP shown in the b) of Fig. 2. Under this mode, all companies build their own WTP and treat their wastewater by themselves. The final discharges of the two modes will have to meet the same standards. All firms are required to discharge according to the first-grade of the National Manufacturing Wastewater Discharge Standards in CSSIP.



a) Mechanism of WTP sharing mode



b) Mechanism of individual WTP mode

Fig. 2. Mechanisms of IWTP and WTPS modes

The overall cost of WTP usually consists of two parts: construction costs and operational costs. The construction costs mainly include equipments and instruments sourcing, engineering cost, control system cost, technology (design) cost, and etc. (Table 1.) The operational costs usually consist of materials inputs, energy consumption, labor salary and welfare, depreciation cost, maintenance expense, and etc. (Gu, 2000) The operational costs of WTP change a lot among different regions and scales. Usually, WTP calculates its overall cost by summing depreciation costs and operational costs. In fact, the construction cost of municipal WTP is often paid by central or local fiscal, and the depreciation cost is usually neglected in China. In recent years, with more and more WTPS being invested and operated by private companies, the depreciation cost is increasingly paid attention to. Up to now almost all the municipal WTPS have not calculated it as a part of overall cost. This expenditure is still covered by local fiscal. However, the depreciation will be considered in the research because the WTP is operated by private company though it was ever invested by local government. Cost-effectiveness analysis (CEA) is one of the techniques of economic evaluation. It is usually expressed with cost-effectiveness ratio. In the research, the cost-effectiveness ratio is calculated with:

$$r_{cea} = \frac{E^T}{C_T^{WTP}} \qquad (1)$$

Where r_{cea} refers to cost-effectiveness ratio; E^T refers to the effect of pollutant elimination; C_T^{WTP} is the overall cost of wastewater treatment. In the research, the effects of pollutant elimination of the two models are the same because we assume the quality of influents and effluents are the same. So we can assume the effect of pollutant elimination (E^T) is one unit, and so their cost-effectiveness can be compared with overall cost of wastewater treatment.

The overall cost of environmental infrastructure sharing model consists of two parts: depreciation cost and operational cost. It can be expressed with:

$$C_T^{WTPS} = C_{depr}^{WTPS} + C_{oper}^{WTPS} \qquad (2)$$

where C_T^{WTPS} refers to the overall cost that companies have to pay for per cubic meter of wastewater treatment; C_{depr}^{WTPS} is the depreciation cost of equipments, instruments, engineering, technology and design, etc. which can be reached as follows:

$$C_{depr}^{WTPS} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N_j}\frac{C_{ij}^{depr}}{n_{ij}}}{Q_{tre}^{WTPS}} \qquad (3)$$

Where C_{depr}^{WTPS} refers to the total depreciation cost of the whole WTPS system which includes pre-treatment systems of companies, wastewater discharge drain system from companies to the WTP, and the WTPS; n_{ij} is life-span (years) of equipment j of company i; n_j is the number of equipments that will be depreciated in company i; M is the number of companies owning pre-treatment utilities for wastewater treatment; Q_{tre}^{WTPS} refers to the total amount of wastewater discharge into the WTPS per year. refers to the fee that company i spends C_{ij}^{depr} on equipment j.

The operational cost can be divided into two parts: pre-treatment in manufacturing factories and the WTPS. It can be calculated as follow:

$$C_{oper}^{WTPS} = \frac{\sum_{i=1}^{M} C_i^{pre} + C_{oper}^{WTP}}{Q_{tre}^{WTPS}} \qquad (4)$$

where C_i^{pre} refers to the operational cost of company i per year; C_{oper}^{WTP} refers to the operational cost of the WTPs per year; Q_{tre}^{WTP} refers to the total treated wastewater of the WTPs per year; M refers to the same object with that of (3).

In IWTP model, every company would have to establish its own utilities to treat the effluent. All their effluents are assumed to meet the standards the present WTP reaches. Under this situation, the overall cost of the wastewater treatment can be calculated as follows:

$$C_T^{IWTP} = \frac{\sum_{i=1}^{M}(C_i^{idepr} + C_i^{ioper})}{\sum_{i=1}^{M} Q_i^{IWTP}} \quad (1 \le i \le M) \qquad (5)$$

where C_T^{IWTP} refers to the overall cost of per cubic meter wastewater treatment under IWTP model; C_i^{idepr} refers to the depreciation cost of company i per year; C_i^{ioper} refers to the operational cost of company i per year; Q_i^{IWTP} refers to the total amount of influent that company has to treat per year; and M refers to the same object with that of (2). Under this situation, there is no WTP sharing. All the data was obtained by questionnaires. Here is a hypothesis that environmental engineers of companies are familiar with wastewater treatment costs.

RESULTS & DISCUSSION

In terms of wastewater discharge, the effluents of 18 companies add up to more than 95% of the total discharge of CSSIP. They are regarded as the core of environmental management by local environmental protection bureau. In the study, 12 of the key supervised companies and other 481 companies are surveyed with questionnaires in which 293 are located in the core area and the other 200 are averagely located in the four towns. The total effluent of the surveyed companies is about 82% of the total discharge of CSSIP. The distribution of the questionnaires is shown in the Table 2.

In the study, 338 companies submitted their questionnaires back of which 5 are confirmed as invalid. All 12 key companies sent back valid questionnaires. Furthermore, in the 333 valid questionnaires, 160 are from the core area and 173 come from the other areas. The valid take-back ratios of the questionnaires in the core and four towns are respectively 54.6% and 86.5%. In terms of invalidity, it means that one or more answers are confirmed invalid such as they are too high to be authentic. In order to confirm the invalidity, we compare the results with the official data of Jiangsu Province. The spatial and ownership distributions of the take-back questionnaires are respectively show in the Table 3 & Table 4.

Table 1. Construction cost and Life span of the WTP Components

	Life-span (Years)
Engineering	20-25
Profession equipments and instruments	10-15
Non-professional devices and instruments	10-15
Control system	10-15
Design and technology	2-5%
others	Loan benefits etc.

Table 2. The questionnaire distribution (samples)

	Core area			Four towns		
	Domestic	Foreign	Others	Domestic	Foreign	Others
Electronics/IT/Software	14	37	5	12	9	7
Precision engineering/mechanical	11	33	3	13	10	8
Food & beverage	1	5	2	17	12	6
Chemical/pharmaceutical & healthcare	3	7	2	20	13	7
Others	10	153	6	25	27	14
Total	39	235	19	87	71	42

Table 3. The spatial distribution of take-back questionnaires (samples)

Items		Core area	Others	Total
Questionnaires distributed		293	200	493
Take-back questionnaires	Valid	160	173	333
	Invalid	1	4	5
R. T. S. (Return To Sender)		25	6	31
Valid take-back ratio (%)		54.6	86.5	67.5

Table 4. The ownership distribution of questionnaire take-back (samples)

Ttems		Domestic	Foreign	Others
Questionnaires distributed		126	306	61
Take-back questionnaires	Valid	105	198	35
	Invalid	4	0	1
R. T. S. (Return To Sender)		28	0	3
Valid take-back ratio (%)		83.3	64.7	57.4

It is shown from table 3 that the take-back ratio of questionnaires in the core area is lower than that of other areas. The results confirm the conclusions we got from interviews that big foreign companies were often not inclined to cooperate with local governments. Usually, foreign companies have large-scale investment and most of them are approved by higher governments. So if they have no environmental issues they will decline the regular environmental monitoring or supervision by local EPB. Comparatively, small and middle foreign firms are more willing to cooperate with local government. Domestic companies usually have a good relationship with local government.

The table 3 also shows that ratio of invalid questionnaires from domestic companies is higher than that of foreign companies. It may be because the managers and engineers of foreign companies have more professional knowledge than that of domestic companies. In addition, the environmental performance of domestic companies is usually worse than that of foreign companies and so they are not willing to disclose their environmental information, especially pollutant discharge information. Domestic companies always complain at their higher stress of environmental protection mainly caused by discriminate investment policies between domestic and foreign companies (Wang et al., 2005).

In addition, other 31 mails are R. T. S. (Return To Sender) in the study. The return reasons can be divided into three kinds: (1) the enterprises had moved. In the last few years, CSSIP began to force some heavy polluted companies move out of the park. For example, about 83 heavy polluted companies were forced to leave in 2002; (2) the enterprises registered in the park are actually not located in the park. Some enterprises established outside the park but enrolled in the park so as to enjoy the preferential economic policies; (3) the enterprises had bankrupted. More and more fierce competitiveness force some enterprises bankrupt and moved to invest in the Central and Western China, especially the small and middle ones.

According to the analysis, the overall wastewater treatment cost under WTPS model varies between 0.0 and 90.0 RMB per cubic meter wastewater. The average overall cost is 35.66 RMB per cubic meter wastewater. In the overall cost, the depreciation cost is 31.2% and the operational cost is 68.8%. With regards to depreciation cost, equipments and instruments is 42%, engineering depreciation is 40%, technology/design is 6%, and the other is 12%. In terms of operational cost, 45.4% is from power consumption, 32.4% is from materials inputs, 18.2% from salary and welfare, and 4.2 from others.

Under IWTP model, the average overall cost of wastewater treatment is 5,542 RMB per cubic meter wastewater. In the overall cost, the depreciation cost is 33% and the operational cost counts 67%. In the depreciation cost, 49% is from equipments and instruments, 45% is from engineering, 2.8% is from technology/design, and the left is 3.2%. In the operational cost, power consumption is 43%, materials inputs is 32%, salary and welfare is 21%, and others is 4%.

The results show that the wastewater treatment cost is 5,542 RMB per cubic meter wastewater under IWTP model. It is much higher than that under the WTPS model (35.66 RMB per cubic meter wastewater). The big difference is probably caused by: (1) under the IWTP model, every company would have to build its own WTP. It would greatly improves the construction cost and furthermore cause an increase of depreciation expense. (2) Under the IWTP model, every company would have to employ its own environmental engineers and operators to operating its WTP. It would greatly increase the operation cost. (3) Under the IWTP model, more land would have to be needed for WTPs and it would increase continuously if the number of companies keeps growing.

Considering the same environmental effects of the two models, the cost-effectiveness ratio (effect/cost) of the WTPS is about 167 times as that of IWTP. That is to say, in terms of wastewater treatment, WTPS model is more cost-effectiveness than IWTP one. It can both greatly reduce the overall cost of wastewater treatment and improve the environmental performance. Based on the analysis of above, the governments should make policies to encourage the WTPS model rather than the IWTP one.

With economic development of CSSIP, more and more companies will invest in the park which would reduce the overall cost due to the scale-enlarging. Furthermore, according to development plan, more and more people will live in the park and manufacturing enterprises will be restricted. Consequently, the sewage will greatly increase and the overall cost of treatment will subsequently decrease.

Of course, in terms of the methodology maybe some people will question the veracity of the model. After all, it comes from questionnaires rather than the factual expenditures. At the same time, the overall cost of virtual model will increase the uncertainty. In fact, it is ever questioned in ref (Rebecca et al, 2004; Matleena, 2006; Qiu et al., 2003). However, the study aims to compare the relative cost-effectiveness of the two models rather than calculate the absolute value. In order to confirm the validity, we ever compared the result to the statistics from six provinces of Eastern China and found that it was very similar.

In fact, companies not only spend money on pretreatment and treatment service, but also pay pollutant discharge fee (PDF) to the local government in China. Even if the discharge of companies meets the requirements of WTP, they will have to pay the PDF. If their discharge cannot meet the requirements, companies will have to pay more PDF according to how much pollutants they discharge. That is to say, the overall cost calculations of the two models are lower than that of the factual cost in practice. But it has similar effects on variations of overall cost of the two models. Of course, there are some problems in the WTPS model. For example, if the WTP stops or runs abnormally due to some unexpected reasons, all the wastewater would have to be discharged directly. So in practice, all WTPS have to establish their own accident pools to store the unexpected discharge. That would increase the overall cost and plays a greater effect on the IWTP model than the WTPS model. However, it would be easier to deal with the accidence under the IWTP model because the amount of discharge under the IWTP model is usually less than that of the WTPS model.

Anyway, it is at least an effective way for pollution control with regards to economic cost in China. The results also explains the fact that why China encourages the development of WTPS model.

All the analysis of above is based on an assumption that all companies abide by the environmental law. That is to say, all companies do not deliberately discharge their wastewater without any treatment. But at present, most industrial parks have not established their own WTPS in China. So it is still a rather common phenomenon for companies to illicitly discharge wastewater without any treatment in China, especially in Central and Western China. Under this situation, the overall cost of the IWTP model maybe less than that of the WTPS model. But this decrease of overall cost is based on the increase of pollutant discharge. It will inevitably cause the environmental pollution. Under the WTPS model, the environmental violation will be avoided effectively because all companies are usually forbidden to discharge directly. Their limber holes are force to connect with waste pipe system before they put into production.

CONCLUSION

As an effective and inexpensive way to approach industrial symbiosis, environmental infrastructure sharing is becoming more and more popular all over the world. The study carries out a case study in CSSIP to verify the cost-effectiveness of environmental infrastructure sharing vs. conventional mode. The research calculates the overall cost of wastewater treatment paid by companies under WTPS model and IWTP model. The results show that under WTPS model, the overall cost in 2006 is 2.34 billion RMB in terms of wastewater treatment. It would be 364.1 billion RMB if it runs under IWTP model. The overall cost of wastewater treatment under WTPS model is only about 0.6 percent of that under IWTP model. The results show that the environmental infrastructure sharing can improve competitive advantage effectively.

ACKNOWLEGEMENT

The research was financially supported by Natural Science Foundation of China (40971302 and 40501027), the Eleventh Five-year Key Technology R&D Program (2006BAC02A15), the China Ministry of Science and Technology (MOST) National Research Initiative Grants Program for State Key Laboratories. This research benefits a lot from the officials of CSSIP committee, especially the deans of environmental protection bureau: Xiaojun Jiang and Xuejun Wang. All of their work and support are highly appreciated. In addition, the author would like to thank the anonymous reviews for their comments and suggestions.

REFERENCES

Abbaspour, M., Lotfi, F. Hosseinzadeh, Karbassi, A.R., Roayaei, E. and Nikoomaram, H. (2009). Development of the Group Malmquist Productivity Index on non-discretionary Factors. Int. J. Environ. Res., 3(1), 109-116.

Adam, C. F., Richard, C. L., Paul, D. C. and Frances, E. B. (2002). Analyzing, Mapping, and Managing Environmental Impacts along Supply Chain. *J. Industrial Ecology*, 5(2), 13-36.

Allenby, B. (2004). Clean Production in Context: An Information Infrastructure Perspective. *J. Cleaner Production*, 12, 833-839.

Boland, J. J., Bell, M. E., Stakhiv, E. E. (1997). *Environmental Infrastructure Management*. Netherlands: the Kluwer Academic Publisher.

Chertow, M. R. and Rachel, D. (2005). Lombardi. Quantifying Economic and Environmental Benefits of Co-located Firms. Environmental Science & Technology, **39 (17)**, 6535-6541.

Chien, M. K. and Shih, L. H. (2007). An empirical study of the implementation of green supply chain management practices in the electrical and electronic industry and their relation to organizational performances. Int. J. Environ. Sci. Tech., **4(3),** 383-394.

Cote, R. and Cohen-Rosenthal, E. (1998). Designing Eco-industrial Parks: A Synthesis of Some Experiences. Journal of Cleaner Production, **6 (3-4)**, 181-188.

Frosch, R. A., Gallopoulos, N. (1989). Strategies for Manufacturing. Scientific American, **261 (3)**, 144-152.

Gale, A. B. (2005). A Method for Measuring the Efficiency Gap between Average and Best Practice Energy Use. Journal of Industrial Ecology, **9 (3)**, 51-65.

Graedel, T. and Allenby, B. (2004). Industrial Ecology. Englewood Cliffs, NJ: Prentice Hall, USA.

Gu, X. C. (2000). The New Stage of Utilizing Foreign Funds and Policy Adjustment. Business Economics and Administration, **10**, 6-9.

Heiner, D. (2005). Exporting the German Model: the Establishment of a New Automobile Industry Cluster in Shanghai. Economic Geography, **81 (1)**, 53-81.

Jonathan, N., Alex D. C. and Heather L. M. (2007). Economic Input-output Life-cycle Assessment of Trade between Canada and United States. Environmental Science & Technology, **41 (5)**, 1523-1532.

Khadka, R. B. and Khanal, A. B. (2008). Environmental Management Plan (EMP) for Melamchi WaterSupply Project, Nepal. Int. J. Environ. Res., 2(1), 87-96.

Lave, L., Cobas, E., Hendrickson, C. and McMichael, F. C. (1995). Using Input-Output Analysis to Estimate Economy-Wide Discharges. Environmental Science & Technology, **29 (9)**, 420-426.

Lisa, H. (2005). Toward Sustainable Management of National Parks in Japan: Securing Local Community and Stake Holder Participation. Environmental Management, **35 (6)**, 753-764.

Marcus, C. R. (2005). Economic Assessment of Municipal Waste Management Systems - Case Studies Using a Combination of Life Cycle Assessment and Life Cycle Costing, Journal of Cleaner Production, **13**, 253-263.

Masahisa, F., and Paul, K. (2004). The New Economic Geography: Past, Present and the Future. Regional Science, **83 (1)**, 139-164

Matleena, K. (2006). Users and Non-users of Conservation Areas: Are There Differences in WTP, Motives and the Validity of Responses in CVM Surveys? Ecological Economics, **59**, 530-539.

Michael, E. P. (1980). Competitive Strategy. New York: the Free Press, USA.

Mohammadrezaie, Sh. and Eskafi, F. (2007). Environmental Performance Evaluation (EPE) of Iran Khodro Co. (IKCO). Int. J. Environ. Res., 1(1), 49-57.

Paul, H. B. (2004). Helmut R. Practical Handbook of Material Flow Analysis. New York, CRC Press LLC.

Peter, L. D. (2002). Approaches for Quantifying the Metabolism of Physical Economies: A Comparative Survey. Journal of Industrial Ecology, **6 (1)**, 65-88.

Peter, S., Martha, P. and David, S. (2002). The Dynamics of Industrial Clustering: International Comparisons in Computing and Biotechnology. Oxford: Oxford University Press, USA.

Ning, Q., Zhao, W., Yue, Y., Chunsheng, Z. and Yuqian, S. (2003). Overall costs Calculation of Wastewater Treatment Plant. China Water & Wastewater, **19 (2)**, 97-98.

Rebecca, A. E., Joseph, P. N. and Glenn, W. S. (2004). A Framework for Net Environmental Benefit Analysis for Remediation or Restoration of Contaminated Sites. Environmental Management, **34 (3)**, 315-330.

Shobeiri, S. M. , Omidvar, B. and Prahallada, N. N. (2007). A Comperative Study of Environmental Awareness among Secondary School Students in Iran and India. Int. J. Environ. Res., 1(1), 28-34.

Sturgeon, T. J. (2003). What Really Goes on in Silicon Valley: Spatial Clustering and Dispersal in Modular Production Networks? Economic Geography, **3 (3)**, 199-225.

Thomas, D., Elinor, O. and Paul, C. S. (2003). The Struggle to Govern the Commons. Science, **302 (12)**, 1907-1912.

Wang, C. M., Wang, L. P. and Li, Y. J. (2005). Study on the Environmental Infrastructure under market mechanism in China: Case study of Sewage and Remains Utilities. Jiangsu Environmental Science and Technology, **18 (4)**, 60-63.

Wolfe, D. and Meric, G. (2004). Clusters from the Inside and Out: Local Dynamics and Global Linkages. Urban Studies, **41 (5/6)**, 1071-1093.

Yuan, Z. W. and Bi, J. (2007). Evolution Mechanism of Eco-Industrial Symbiosis Network and Its Analytical Framework. *ACTA* Ecological Sinica, **27 (8)**, 1-7.

Zeng, X. G. (2006). Governance under Market-based Mechanism of Environmental Infrastructure. China Environmental Protection Industry, **4**, 10-13.